Robert F. McCauley (SBN 162056)
robert.mccauley@finnegan.com
Arpita Bhattacharyya (SBN 316454)
arpita.bhattacharyya@finnegan.com
Jeffrey D. Smyth (SBN 280665)
jeffrey.smyth@finnegan.com
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, LLP
3300 Hillview Avenue
Palo Alto, California 94304
Telephone: (650) 849-6600
Facsimile: (650) 849-6666

Attorneys for Plaintiff and Counterdefendant
ASETEK DANMARK A/S and
Counterdefendant ASETEK USA, INC.

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

ASETEK DANMARK A/S,

Plaintiff and Counterdefendant,

ASETEK USA, INC.,

Counterdefendant,

v.

COOLIT SYSTEMS, INC.,

Defendant and Counterclaimant,

COOLIT SYSTEMS USA INC., COOLIT SYSTEMS ASIA PACIFIC LIMITED, COOLIT SYSTEMS (SHENZHEN) CO., LTD.,

Defendants,

CORSAIR GAMING, INC. and CORSAIR MEMORY, INC.,

Defendants.

CASE NO. 3:19-cv-00410-EMC

EXHIBIT AA TO THE DECLARATION OF ARPITA BHATTACHARYYA IN SUPPORT OF ASETEK DANMARK A/S AND ASETEK USA, INC.'S MOTION FOR PARTIAL SUMMARY JUDGMENT

Date: May 5, 2022
Time: 1:30 PM
Location: Courtroom 5, 17th Floor
Judge: Hon. Edward M. Chen

EXHIBIT AA

TO THE DECLARATION OF ARPITA BHATTACHARYYA IN SUPPORT OF ASETEK DANMARK A/S'S MOTION FOR PARTIAL SUMMARY JUDGMENT

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

ASETEK DANMARK A/S,
Plaintiff and Counter-Defendant,

v.

COOLIT SYSTEMS, INC.,
Defendant and Counter-Claimant,

AND

CORSAIR MEMORY, INC.,
Defendant.

CASE NO. 3:19-cv-00410-EMC

UPDATED EXPERT REPORT OF DR. JOHN P. ABRAHAM REGARDING INVALIDITY OF ASETEK DANMARK A/S'S ASSERTED PATENT CLAIMS

I. SUMMARY

1. I have been retained by CoolIT Systems, Inc. ("CoolIT") as a technical expert to provide opinions regarding the validity or invalidity of the following patent claims (collectively the "asserted claims") from five patents that I understand are owned by Asetek Danmark A/S ("Asetek") and asserted against CoolIT in the above-referenced litigation:

Asserted Patent	Asserted Claim(s)
U.S. Patent No. 8,240,362 ("'362 patent")	17, 19
U.S. Patent No. 10,599,196 ("'196 patent")	1, 2, 13
U.S. Patent No. 10,613,601 ("'601 patent")	1, 6, 11, 12
U.S. Patent No. 10,078,354 ("'354 patent")	1, 8, 15
U.S. Patent No. 10,078,355 ("'355 patent")	1, 2, 6

2. It is my opinion that all of the asserted claims are invalid under one or more of 35 U.S.C. §§ 102, 103, and/or 112. My opinions and the bases and reasons for them are set forth in this report.

3. I am being compensated at a rate of $350 per hour, plus reimbursement of expenses, for my time spent working on this matter. I do not have a financial interest in the outcome of this matter.

4. I reserve the right to modify or supplement my opinions, as well as the bases for my opinions, including based on the nature and content of the documentation, data, proof, and other evidence or testimony that Asetek or its experts may present, on any additional discovery or other information provided to me or found by me in this matter, or on further instructions or orders from the Court. In addition, should I be called to testify at trial, I may provide a tutorial regarding the materials I discuss in this report, including all exhibits. This tutorial may further include demonstratives such as computer graphics, videos, screenshots, and other presentation material regarding the asserted claims and the technology described therein.

II. BACKGROUND AND QUALIFICATIONS

5. My qualifications for forming the opinions set forth in this expert report are summarized here and more fully detailed in my curriculum vitae ("CV") attached hereto as Appendix A. My CV contains a full list of my publications and a list of all other cases in which I have testified as an expert.

6. I am a Professor and Program Director of the Masters in Science of Mechanical Engineering at the University of St. Thomas, in St. Paul, Minnesota. There I specialize in

thermal sciences, which describe the science of flow (flow of heat, flow of gases, flow of liquids, etc.) and physical processes that occur during these flows. I believe my educational and work experience, as summarized below, qualify me as an expert in the field of mechanical engineering, with an emphasis on thermal sciences. My experience encompasses both fluid flow and heat transfer. In particular, I have performed research and consulted for numerous companies on issues related to heat transfer and flow and electronics cooling.

7. I earned a Bachelor of Science degree in Mechanical Engineering with a minor in Mathematics from the University of Minnesota – Twin Cities in 1997. In 1999, I earned a Master of Science ("MS") degree from the University of Minnesota – Twin Cities, in the area of thermal-fluid sciences. My MS research project was in the area of air flow, dehumidification, and water-vapor transport. In 2002, I earned a Ph.D. degree in Mechanical Engineering in the area of thermal-fluid sciences also from the University of Minnesota – Twin Cities, with my thesis on fluid and heat flows in enclosures.

8. In 2002, I joined the faculty of University of St. Thomas in St. Paul, Minnesota, as an Assistant Professor in the Engineering Department. In 2008, I became an Associate Professor at the University of St. Thomas in the Engineering Department. In 2013, I was promoted to a full professorship at the University of St. Thomas in the Engineering Department, where I currently teach in the area of thermodynamics, heat transfer, and fluid mechanics.

9. I have received several honors and awards during my teaching career, including the University of St. Thomas Engineering Professor of the Year in 2005; the University of St. Thomas John Ireland Award in 2009; and the University of St. Thomas Professor of the

Year Award in 2016.

10. I have published peer-reviewed scientific papers detailing my work in heat transfer, fluid flow, and temperature management of electronics.

11. I have presented my work on these topics at technical conferences.

12. I have been involved in the design and invention concerning flows in structures. For example, I have published approximately five peer-reviewed studies on flow and distribution of fluids through manifolds. I have produced approximately 350 publications, books, book chapters, conference presentations, and patents in areas including heat transfer, fluid flow, and analysis of the structures that convey fluids for heating and cooling. Many of these studies relate to the flow of fluids (both liquids and gases) through tubes or conduits. I am also a named inventor on multiple patents that deal with flow and heat transfer.

13. I am an editor of two highly rated series: Advances in Heat Transfer (John Abraham, John Gorman & Dr. Wolodymyr Minkowycz, eds., 2020) and Advances in Numerical Heat Transfer (W.J. Minkowycz, E.M. Sparrow & J.P. Abraham, eds., 2012). These series bring together world leaders in the thermal sciences, and I am responsible for the review and editing of the submissions. The submissions include studies on heat transfer and on air and gas flow in conduits and on phase change (transfer of vapor to a liquid (condensation) or liquid to a vapor (evaporation)).

14. I have given numerous presentations on electronics cooling techniques and related heat transfer processes. Some examples include:

- *Ephraim M. Sparrow, John P. Abraham, and Paul Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, ASME International*

Mechanical Engineering Congress and R & D Expo, Washington, DC, November, 2003.

- *Ronald Major and John Abraham, The Application of Thermal Analysis on a Disk Array, Fluent's 2005 CFD Summit, Detroit, MI, June 7-8, 2005.*

- *E.M. Sparrow, J.P. Abraham, P.W. Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, Journal of Heat Transfer, Vol. 127, pp. 27-33, 2005.*

- *P.W. Chevalier, J.P. Abraham, and E.M. Sparrow, The Design of Cold Plates for the Thermal Management of Electronic Equipment, Journal of Heat Transfer Engineering, Vol. 27, pp. 6-16, 2006.*

- *J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, A Quasi-Analytical Method for Fluid Flow in a Multi-Inlet Collection Manifold, Journal of Fluids Engineering, Vol. 129, pp. 579-586, 2007.*

- *J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Attainment of Flowrate Uniformity in the Channels that Link a Distribution Manifold to a Collection Manifold, Journal of Fluids Engineering, Vol. 129 (9), pp. 1186-1192, 2007.*

- *J.C.K. Tong, E.M. Sparrow, and J. P. Abraham, Geometric Strategies for Attainment of the Identical Outflows Through all of the Exit Ports of a Distribution Manifold in a Manifold System, Applied Thermal Engineering, Vol. 29, 3552-3560, 2009.*

- *J.P. Abraham and G.S. Mowry, B.D. Plourde, Analysis of Thermal and Fluid Flow Problems, Thermal Packaging and Small Business Innovation Workshop, Eagan, MN, October 5-6, 2010.*

- *E.M. Sparrow, J.M. Gorman, K.S. Friend, and J.P. Abraham, Flow Regime Determination for Finned Heat Exchanger Surfaces with Dimples/Protrusions, Numerical Heat Transfer, Vol. 63, pp. 245-256, 2012.*

- *J.M. Gorman, EM. Sparrow, J.P. Abraham, and G.S. Mowry, Operating Characteristics and Fabrication of a Uniquely Compact Helical Heat Exchanger, Applied Thermal Engineering, Vol. 5, pp. 1070-1075, 2012.*

- *E.M. Sparrow, J. M. Gorman, and J.P. Abraham, Quantitative Assessment of the Overall Heat Transfer Coefficient U, Journal of Heat Transfer, Vol. 135, paper no. 061102, 2013.*

- *J.M. Gorman, M. Carideo, E.M. Sparrow, and J.P. Abraham, Heat Transfer and Pressure Drop Comparison of Louver- and Plain-finned Heat Exchangers Where*

One Fluid Passes Through Flattened Tubes, Case Studies in Thermal Engineering, Vol. 5, pp. 122-126, 2015.

- *D. Nguyen, J. M. Gorman, E.M. Sparrow, and J.P. Abraham, Convective Heat Transfer Enhancement Versus Disenhancement: Impact of Fluid-Mover Characteristics, Applied Thermal Engineering, Vol. 90, pp. 242-249, 2015.*

- *J.M. Gorman, E., M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Transfer Design Methodology Treating a Heat Exchanger Device and its Fluid-Mover Partner as a Single System, Heat Transfer Engineering, Vol. 38, pp. 841-852, 2017.*

15. Over the past 20 years, I have served as a consultant to numerous companies to aid in the design or evaluation of fluid flow systems for electronics cooling. Examples of these companies include ADC Telecom (2000), MicroControl Company (2001), Lockheed Martin, (2007), and Medtronic (2012).

16. I have performed my own studies of cooling of electronics, including computer systems and Central Processing Units ("CPUs").

17. I teach or have taught courses that cover flow, heat transfer, and thermal management of electronics. I teach both graduate and undergraduate courses. Each semester I train students to solve problems related to the cooling of heat-generating devices such as CPUs.

18. As part of my education, I have taken courses in thermodynamics, fluid mechanics, and heat transfer (as part of my undergraduate and graduate degrees).

19. A representative sample of the journals I have published in include *International Journal of Heat and Mass Transfer, International Journal of Heat and Fluid Flow, Numerical Heat Transfer, Advances in Heat Transfer, Journal of Thermal Science and Engineering Applications, Frontiers in Heat Transfer, Applied Thermal Engineering, Journal of Fluids Engineering, Journal of Heat Transfer, Journal of Heat Transfer Engineering,* as examples.

20. A full list of my research works is provided in my CV, which is attached to this report as Appendix A.

III. MATERIALS CONSIDERED

21. In addition to my experience in this field as summarized above, the materials that I have considered in forming the opinions set forth in this report include all references cited in this report as well as the list of materials attached as Appendix B to this report.[1]

IV. APPLIED LEGAL STANDARDS

22. I am not a lawyer or legal expert, and I am not offering any opinions regarding the law. Although I am not an attorney, I have been instructed on the applicable law by counsel for CoolIT and informed by my previous experience as an expert witness in other patent matters as described in my CV attached hereto. I have also been provided with the Court's orders and opinions regarding claim construction, and I have applied those constructions in formulating my opinions.

[1] I understand that CoolIT has submitted expert declarations from Marc Hodes, Ph.D. in IPR2020-00522 and IPR2020-00523 and from Himanshu Pokharna, Ph.D. in IPR2021-01195 and IPR2021-01196 to address subject matters that overlap with those being discussed in my report here (e.g., same or similar claim scopes or limitations, same prior art references, etc.). I have carefully reviewed one or more of Dr. Hodes's and Dr. Pokharna's declarations (IPR2020-00522, Exs. 1003 and 1020; IPR2020-00523, Exs. 1003 and 1012; IPR2021-01195, Ex. 1003; and IPR2021-01196, Ex. 1003) and have adopted materials from their declarations, to the extent I agree with, in this report.

A. Claim Construction

23. I understand that there are two types of claims: independent claims and dependent claims. I understand that an independent claim stands alone and includes only the limitations it recites. I understand that a dependent claim, on the other hand, is a claim that depends on another claim. I understand that dependent claims include all of the limitations recited in the dependent claim as well as any limitations included in the corresponding independent claim the dependent claims depend from.

24. I understand that, before making a determination of whether the asserted claims are valid, the claims must be construed on a limitation-by-limitation basis. I understand that the Court has construed some terms or phrases as a matter of law. I understand that claim terms not construed by the Court are to be afforded their plain and ordinary meaning as used in the claims and as would be understood by one of ordinary skill in the art at the time of the invention. I understand that this person of ordinary skill in the art at the time of the invention is assumed to have read the claim terms in light of the entire patent record, including the other claims, the patent specification, and the patent prosecution history. I have interpreted the claim terms not construed by the Court in light of this understanding.

25. I understand that to properly understand the meaning of claim terms, one should first consider the intrinsic evidence, which includes the claim language itself, the patent specification, and the patent's prosecution or post-issuance history created before the Patent Office. For example, the patent specification may show that the inventor used words or terms in a manner inconsistent with their plain and ordinary meaning. Specifically, I understand that where the specification reveals a special definition given to a claim term by the patentee that differs from the meaning it would otherwise possess, the inventor's

lexicography governs. I understand that the prosecution history of the patent may also provide guidance in construing a claim term. For example, the prosecution history may show that the patent applicant has limited the scope of some or all of the claims during prosecution, either affirmatively or by implication.

26. I understand that if the intrinsic evidence is not conclusive regarding the meaning of a particular claim term, extrinsic evidence may also be used to determine its meaning. I understand that extrinsic evidence may be used, for example, to help determine what a person of ordinary skill in the art at the time of the invention would understand the claim term to mean. Extrinsic evidence may include, for example, dictionaries, technical treatises, journals, articles, or expert testimony.

B. Claim Construction Issued in this Case

27. I understand that the following terms or phrases have been construed by the Court or stipulated to by the parties in this case for the ’362, ’196, ’601, ’354, and ’355 patents (collectively “asserted patents”). I have applied these constructions in my analysis.

Term or Phrase	Construction
“reservoir”	“single receptacle defining a fluid flow path”
“chamber”	“compartment within the reservoir”
“double-sided chassis	“two-sided frame”
“stator”	“stationary parts of the motor that perform or support an electrical or magnetic function of the motor”
“either a first end or a second end of the thermal exchange chamber”	“either the first end or the second end of the thermal exchange chamber”
“direct the cooling liquid from the central region toward the perimeter of the lower chamber”	Plain and ordinary meaning

C. Presumption of Validity

28. I understand that, in deciding whether to issue a patent, the United States Patent and Trademark Office ("USPTO") examines the patent specification, its claims, and relevant prior art references to determine whether the patent application and its claims meet the requirements for patentability. I understand that the law recognizes that claims issued by the USPTO are presumed valid. I also understand that this presumption of validity can only be overcome if the party seeking to invalidate the claim proves that the claim is invalid by clear and convincing evidence.

D. Anticipation by Prior Art Under Sections 102(a), (b), and (e)

29. I understand that a person cannot obtain a patent if someone else already made an identical invention, which is referred to as "anticipation." I understand that to anticipate a claim, each and every element in the claim must be, as properly construed, present in a prior art reference either expressly or inherently.

30. I understand that, in determining whether an element of the claimed invention is found expressly in the prior art, one should take into account what a person of ordinary skill in the art would have understood from his or her examination of the particular prior art. I understand that to establish anticipation through inherency, the extrinsic evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill in the art.

E. Obviousness Under Section 103

31. I understand that, for a claim to be invalid as obvious, the party asserting invalidity must identify prior art references that alone or in combination with other prior art references

would have rendered the claim obvious to one of ordinary skill in the art at the time of the invention. I understand that the disclosures of these references also may be combined with information known to persons skilled in the art at the time of the invention, and understood and supplemented in view of the common sense of persons skilled in the art at the time of the invention, including any statements in the asserted patents and in the intrinsic record of the asserted patents and related applications. I understand that obviousness is a question of law based on underlying factual findings: (1) the scope and content of the prior art; (2) the differences between the claims and the prior art; (3) the level of ordinary skill in the art; and (4) secondary considerations of non-obviousness.

32. I understand that a conclusion of obviousness may be based on a combination of prior art references, particularly if the combination of elements does no more than yield predictable results. I understand that it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in a way the claimed invention does.

33. I understand that in determining whether a combination of prior art references renders a claim obvious, it may be helpful to consider whether there is some teaching, suggestion, or motivation to combine the references and a reasonable expectation of success in doing so. I understand, however, that the teaching, suggestion, or motivation to combine inquiry is not required and may or may not be relied upon in lieu of the obviousness analysis outlined above.

34. I understand that the following exemplary rationales may lead to a conclusion of obviousness: the combination of prior art elements according to known methods yields predictable results; the substitution of one known element for another obtains predictable

results; the combination of prior art elements consists of choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success ("obvious to try"); and the use of known techniques to improve similar devices in the same or similar way. For example, I understand that the fact that another person contemporaneously and independently created the same invention claimed in an asserted patent can serve as an indication that the invention was obvious.

35. I understand that in evaluating whether patent claims are invalid as obvious, secondary considerations of non-obviousness are considered. I understand that the secondary considerations of non-obviousness are considered with the balance of obviousness evidence in the record to act as a check against impermissible hindsight bias. I further understand that the patentee must establish a nexus between the merits of the claimed invention and the evidence of non-obviousness in order to give such considerations substantial weight in the determination of non-obviousness.

36. I understand that the burden of presenting evidence of secondary considerations of non-obviousness is on the patentee. I also understand that the proponent of the evidence of secondary considerations bears the burden of showing that a nexus exists between the claimed features of the invention and the objective evidence offered to show non-obviousness.

37. I understand that the secondary considerations of non-obviousness include commercial success, long-felt but unsolved needs, copying, praise, teaching away from the claimed invention by the prior art, unexpected results, industry acceptance, failure of others, and skepticism by experts.

F. Obviousness-Type Double Patenting

38. I understand that the doctrine of obviousness-type double patenting prohibits claims in a second patent which define merely an obvious variation of an invention claimed by the same inventor in an earlier patent. I understand that the object of the doctrine of double patenting is to prevent the unjustified or improper extension of a patent, or of obvious variations on it, beyond its term. For example, if a later-expiring patent is merely an obvious variation of an invention disclosed and claimed in an earlier-expiring patent, the later-expiring patent is invalid for obviousness-type double patenting. I understand that a terminal disclaimer is a permissible means to overcome the prohibition on double patenting when it aligns the expiration dates of an inventor's several patents that claim mere obvious variations of the same invention to create a single term of limited exclusivity.

G. Section 112 (Written Description / Enablement)

39. I understand that patent claims can be invalid if the patent specification fails to comply with the written description and enablement requirements of 35 U.S.C. § 112. ("The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same . . .").

40. I understand that to satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the full scope of the claimed invention at the time of filing the patent application.

41. I understand that to satisfy the enablement requirement, a patent specification must teach those skilled in the art how to make and use the full scope of the claimed invention without undue experimentation. I also understand that it is the specification, not the knowledge of one skilled in the art, that must supply the novel aspects of an invention in order to constitute adequate enablement and that the patentee is required to provide an adequate enabling disclosure in the specification and cannot simply rely on the knowledge of a person of ordinary skill in the art to serve as a substitute for missing information in the specification.

H. Inequitable Conduct

42. I understand that patent applicants, prosecution counsel, and patent owners appearing before the USPTO owe a duty of candor and good faith to the USPTO, such as during prosecution of a patent. I understand that a breach of this duty may constitute inequitable conduct if an applicant, with intent to mislead or deceive the USPTO, fails to disclose material information or otherwise engages in egregious misconduct such as submitting materially false information to the USPTO during prosecution of a patent. I further understand that a reference is material if the patent examiner would not have allowed a claim during prosecution of the patent had the examiner been aware of the undisclosed prior art. I reserve my right to opine on the unenforceability of the asserted patents.

V. PERSON OF ORDINARY SKILL IN THE ART

43. I understand that a Person of Ordinary Skill in the Art ("POSA") is a hypothetical person who is assumed to be aware of all pertinent art, thinks along conventional wisdom in the

art, and is a person of ordinary creativity. Hereafter, when I use the term "POSA," it refers to a POSA at the time of the invention.

44. After reviewing the already-mentioned materials, my opinion is that the relevant art pertains to fluid flow (gases and liquids), devices that cause fluid flow, heat transfer, and thermal management of electronics or other heat-generating devices.

45. In determining who would be a POSA, I considered at least the following criteria: (a) the types of problems encountered in the art, (b) prior art solutions to those problems, (c) the rapidity with which innovations are made; (d) the sophistication of the technology; and (e) the education level of active workers in the field.

46. In my opinion, a Person having Ordinary Skill in the Art (POSA) at the time of the effective filing dates of the asserted patents would have been trained or knowledgeable regarding liquid cooling systems for computer and/or similar systems, would have earned at least a bachelor's degree, such as a B.S. (bachelor of science), or equivalent thereof, in electrical or mechanical engineering or a closely related field (involving, e.g., heat transfer, fluid flow, and/or thermodynamics, etc.), and would have possessed at least two or three years of industrial or other professional experience in liquid cooling systems for computer systems or in similar systems involving heat transfer.

VI. TECHNOLOGY BACKGROUND FROM THE ASSERTED PATENTS.

47. The asserted patents deal with thermal management of heat generating devices, such as electronics components used in computer systems.

48. The '196 patent issued on March 24, 2020, from Application No. 15/991,384, which was filed on May 29, 2018 and claiming a priority date of May 6, 2005. I have used

May 6, 2005 as the priority date for this patent for purposes of this report, but I am not offering an opinion as to whether or not the asserted claims are entitled to this priority date.

49. The ’601 patent issued on April 7, 2020 from Application No. 15/991,375, which was filed on May 29, 2018 and claiming a priority date of November 8, 2004. I have used November 8, 2004 as the priority date for this patent for purposes of this report, but I am not offering an opinion as to whether or not the asserted claims are entitled to this priority date.

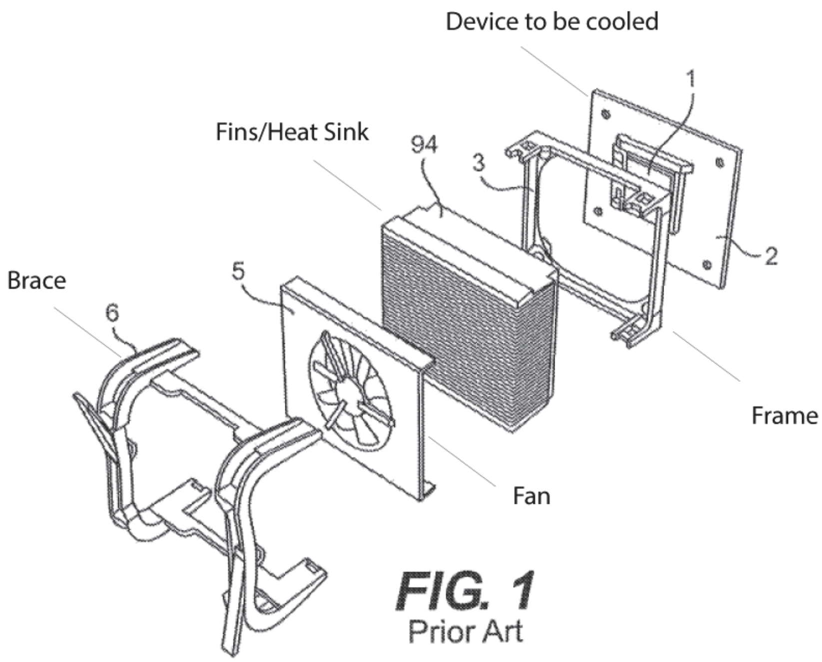
50. The ’362 patent was issued on August 14, 2012 from Application No. 12/826,768, which was filed on June 30, 2010 and claiming a priority date of November 7, 2003. I have used November 7, 2003 as the priority date for this patent for purposes of this report, but I am not offering an opinion as to whether or not the asserted claims are entitled to this priority date.

51. The ’355 patent issued on September 18, 2018, from Application No. 15/626,706, which was filed on June 19, 2017 and claiming a priority date of May 6, 2005. I have used May 6, 2005 as the prior date for this patent for purposes of this report, but I am not offering an opinion as to whether or not the asserted claims are entitled to this priority date.

52. The ’354 patent issued on September 18, 2018 from Application No. 15/626,393, which was filed on June 19, 2017 and claiming a priority date of November 8, 2004. I have used November 8, 2004 as the priority date for this patent for purposes of this report, but I am not offering an opinion as to whether or not the asserted claims are entitled to this priority date.

53. The asserted patents discuss different strategies to cool heat-generating components, such as computer processors. A first method utilizes air to remove heat from the components, as

shown here. With an air flow system, typically a heat sink or fins arranged in an array are attached to a heat-generating device. Heat conducts into the fins and then passes into air that is blown by a fan through the fin array.



’196 patent, Fig. 1

54. Another way to cool electronic components is to use liquid as an intermediary. Liquid, because of its superior heat transfer capabilities compared to gases, is routed to the heat-generating components. The heat is transferred into the liquid. The liquid is then brought to a radiator at which location air is blown over the liquid’s tubing. Consequently, heat is transferred from the liquid to an airstream. Next, the liquid travels to a (prior-art) liquid reservoir and a pump that causes the liquid to flow in its tubing. These components are described in the following image, which is taken from the ’196 patent.

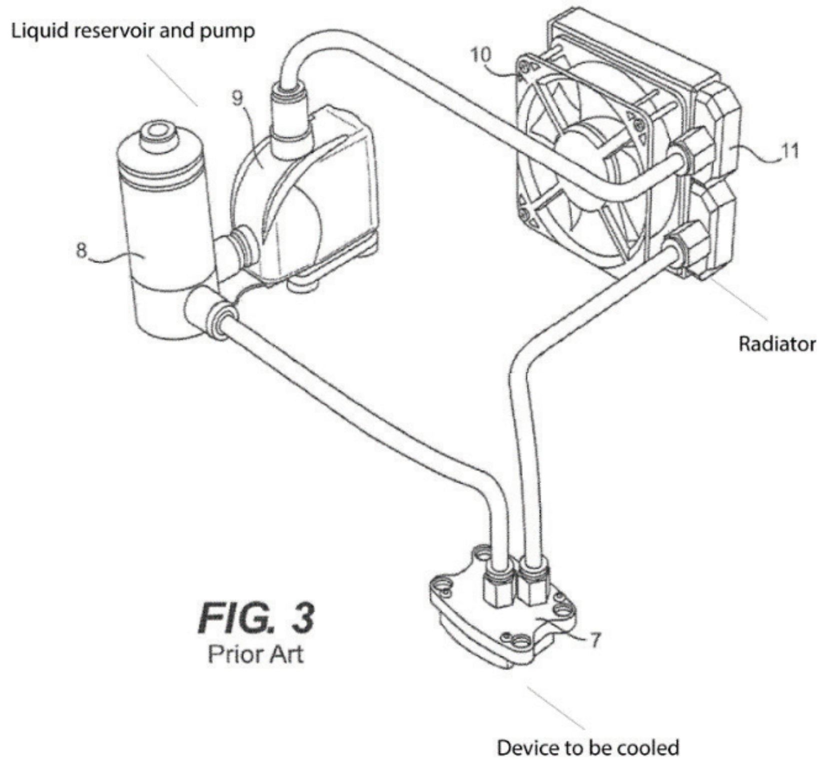
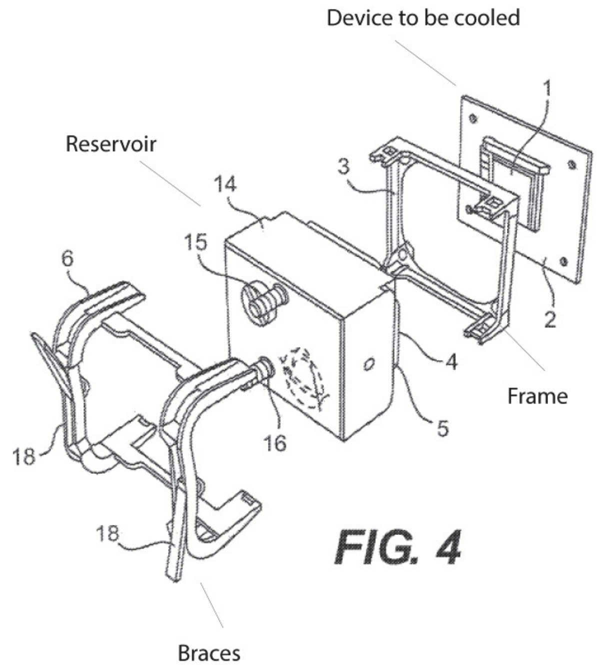


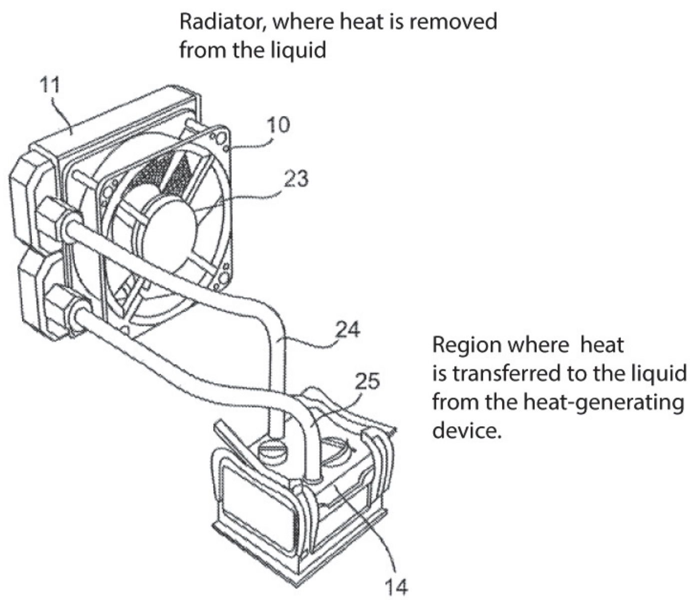
FIG. 3
Prior Art

’196 patent, Figure 3

55. The asserted patents claim to provide improvements to the prior art because of their compact size and cooling efficiency. As shown in the following image, the asserted patents describe a fluid reservoir that is in close proximity to the heat-generating component. In the subsequent image, there is a depiction of the reservoir (14) in proximity to a heat-generating component and a radiator (11) that is connected to the reservoir by fluid-conveying tubes. Heat that is transferred to the liquid at the heat-generation location is subsequently removed from the liquid at the radiator.



’196 patent Figure 4



’196 patent Figure 7

56. The asserted patents claim that the patented technology provides a small and compact liquid-cooling solution that is more efficient than existing air-cooling arrangements and can be produced at a low cost. The asserted patents also claim that the patented device may be easy to use and implement and requires a low level of maintenance, or no maintenance. It is further asserted that the patented device can be used with existing CPU systems and existing computer systems (e.g., ’196, col 1, lines 57-67; ’362 col. 1 line 53-63; ’601 col 1, line 62 through col. 2, line 5).

VII. ANALYSIS OF VALIDITY OF THE ’362 PATENT PURSUANT TO 35 U.S.C. § 103

57. I have considered the following prior-art references and their combinations in forming my opinions on invalidity of claims 17 and 19 of the ’362 patent pursuant to § 103:

- U.S. Patent, 6,894,899 (Wu)
- U.S. Patent 6,019,165 (Batchelder)
- JP 2002-151638 (Shin)
- KR 2003-0031027 (Ryu)
- U.S. Patent Application 2004/0052663 (Laing)
- ZL 02241576.9Y (Yu)

58. It is my opinion that claims 17 and 19 of the ’362 patent are invalid by obviousness under the following grounds:

Ground	Combination
1	Shin in view of Wu (claims 17 and 19)
2	Shin in view of Batchelder (claims 17 and 19)
3	Shin in view of Laing (claims 17 and 19)

Ground	Combination
4	Ryu in view of Wu (claims 17 and 19)
5	Ryu in view of Batchelder (claims 17 and 19)
6	Batchelder in view of Shin (claims 17 and 19)
7	Batchelder in view of Ryu (claims 17 and 19)
8	Batchelder in view of Wu (claims 17 and 19)
9	Yu in view of Wu (claims 17 and 19)

59. The asserted claims of the ’362 patent are recited below. Claim 18 is included because asserted claim 19 depends from it.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard, the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir;

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the/ cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

A. Ground 1 – Shin in View of Wu

60. It is my opinion that Shin, in view of Wu and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

61. It is my understanding that the preamble to claim 17 is not limiting. But, to the extent the preamble is determined to be limiting, Shin discloses or teaches this preamble. Shin discloses or teaches a method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system.

62. The title of Shin is "COOLING DEVICE FOR ELECTRONIC EQUIPMENT."

63. The abstract of Shin clearly states that it is a liquid cooling system. The abstract states "*A cooling structure for compactly mounting a liquid cooled heat sink and pump inside a case.*"

64. Shin makes clear that it is intended to be used for cooling electronic components positioned on the motherboard of a computer system; as evidenced by the following representative but non-exhaustive passages.

> [Means for solving the problem] To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink.

Shin [0007]

[0008] Furthermore, the pump is secured to the top part of the liquid cooled heat sink, forming a structure that allows the pump and liquid cooled heat sink to be handled as an integral structure.
[0009] Furthermore, a structure is formed wherein the liquid coolant discharge section of the pump is directly connected to the liquid cooled heat sink by means of a pipe, etc.
[0010] Furthermore, an arrangement is adopted whereby the pump operates from a direct current power supply.
[0011] Moreover, a structure is formed whereby the pump is secured to the liquid cooled heat sink across a vibration absorption member or the like.
[0012]

Shin [0008-0011]

[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin [0012]

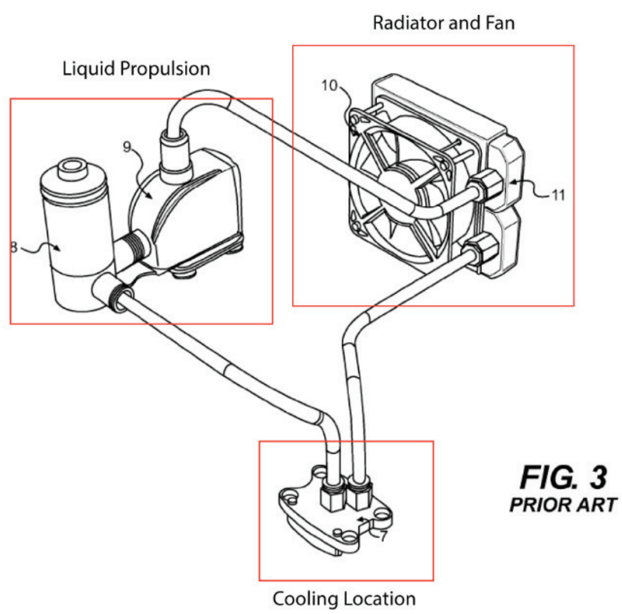
[0013] In the present embodiment example, a structure is employed whereby the pump 5 is secured to the liquid cooled heat sink 4 across a vibration absorbing member 19. Thus, a structure is formed whereby the vibration of the pump 5 does not readily have a direct effect on the CPU or other electronic component. The pump 5 is connected to the

Shin [0013]

[0030] Furthermore, an integral component kit comprising this pump and liquid cooled heat sink can be installed instead of an air cooled heat sink with fan as frequently used in conventional personal computers and the like, making it possible to adopt a liquid cooling system into electronic devices without difficulty. If the power supply of the pump is compatible with the fan power supply for an air cooled heat sink with fan, the adoption of course becomes even easier.

Shin [0030]

65. To the extent this preamble was not disclosed or taught by Shin, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics. This is shown by the following figures, which were cited as prior art in the asserted patents:



’362 Figure 3, prior art

66. To the extent this preamble was not disclosed or taught by Shin in view of the knowledge of a POSA, it was disclosed or taught by Wu. The title of Wu is "INTEGRATED FLUID COOLING SYSTEM FOR ELECTRONIC COMPONENTS."

67. The Wu abstract confirms this focus, as shown here:

(57) **ABSTRACT**

An improved cooling system designed for electronic components such as a central processing unit of a computer with an integrated unit comprising a radiation housing, an absorption housing having a coolant store unit, an absorption layer between the coolant store unit and the electronic component and a circulation generation unit which causes a coolant to flow from the coolant store unit to the absorption layer and back to the coolant store unit through a conduit.

Wu Abstract

BACKGROUND OF THE INVENTION

The present invention relates to a fluid cooling system designed for electronic components, with radiation and absorption incorporated in an integrated unit, and more particularly, to a central processing unit ("CPU") radiator with internal circulation integral mode liquid cooling system.

Wu Column 1 lines 12-17

DETAILED DESCRIPTION OF THE INVENTION

The present invention is an improved cooling system designed for electronic components such as a central pro-

Wu, Column 2 lines 64-67

3

cessing unit (CPU) of a computer, super power tube, integrated chip, or the like and any similar electronic devices that use a radiation sheet for heat transfer or thermal management. One preferred embodiment is directed to a cooling system, i.e., radiating system designed for a CPU comprising a coolant **(102)** and an integrated radiation housing and absorption housing or section. It is contem-

Wu Column 3, lines 1-7

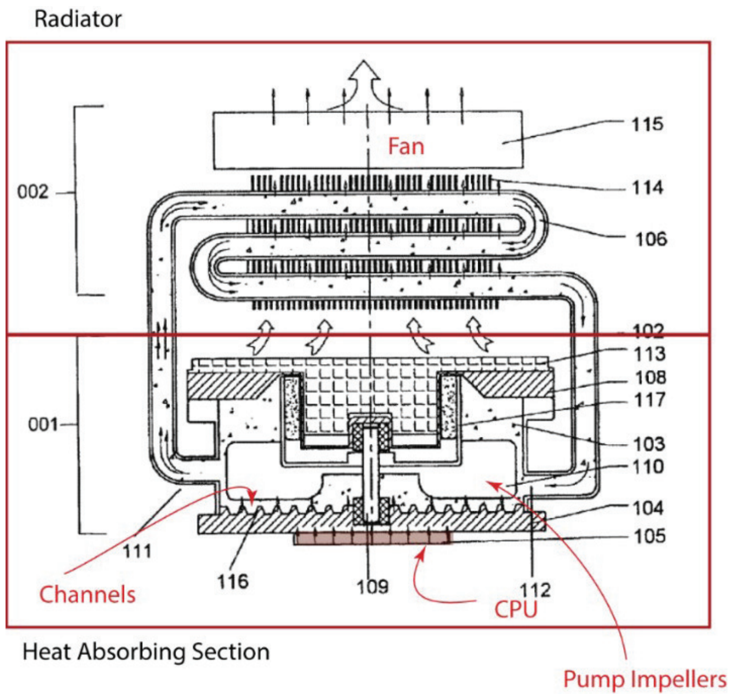
Another embodiment is directed to the process of cooling. More specifically, the CPU **(105)** triggers the cooling system **(101)** when it is in operation and generates heat. The absorption layer of the cooling system absorbs the heat generated by the CPU as they are in contact or direct contact. The coolant **(102)** in the coolant storage unit **(103)** in turn absorbs the heat from the absorption layer. At the same time,

Wu Col. 3, lines 47-54

FIG. **1** illustrates the cross-sectional view of one embodiment of the present invention. The cooling system **(101)** comprises a coolant **(102)** and an integrated radiation housing or section and absorption housing having a coolant storage unit **(103)** in absorption section, an absorption layer **(104)** between the coolant storage unit and the CPU **(105)** and a conduit **(106)**. The cooling system **(101)** is mounted on the top of the CPU with four fixing screws with the absorption layer in direct contact with the CPU as well as the coolant **(102)**. The cooling system **(101)** has the same power supply (not shown) as that of the CPU **(105)**, typically 12V DC, so when the CPU is in operation in which heat is generated, the cooling system **(101)** will be turned on. As shown in FIG. **1**, the absorption layer **(104)** is the base of the cooling system **(101)** and in order for the absorption layer **(104)** to absorb heat from the CPU quickly it is made of materials having a high heat conductivity such as bronze, copper (preferably red copper tube), aluminum and the like or alloys thereof. It will be appreciated that any thermally conductive material is contemplated. Further contemplated equivalents include mixtures of plastic and copper powder or the like. The other side of the absorption layer, the side that is in contact with the coolant, is made with a number of grooves **(116)** to increase the contact area between the coolant and the absorption layer so that more heat can be transferred about quickly. The absorption layer in the preferred embodiment has about 10 to 20 grooves and more preferably, about 10 to 15 grooves. The absorption layer

Wu Col 4, lines 10-37

68. Wu also discloses the Preamble in its depicted embodiments. For instance, as shown below. A POSA would have been motivated to use a liquid cooling system to provide cooling to an electronic heat-generating device. Liquid cooling is a very effective way of removing heat from a device and transferring the heat to a distant location. Liquid cooling is more efficient than other cooling methods, for example air cooling.

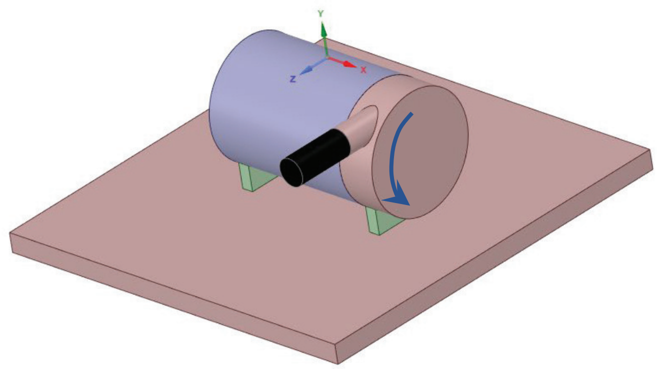


Wu – Figure 1

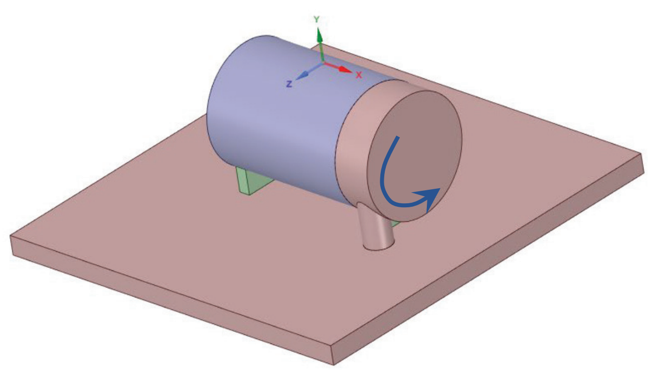
17(a) … a reservoir … the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

69. As discussed above, it is my understanding that the parties have stipulated to the following construction for "reservoir": "single receptacle defining a fluid flow path." The claim language also requires the "reservoir" to include "an upper chamber and a lower chamber." To the extent Shin does not disclose these limitations, they would have been obvious in view of the experience, education, and training of a POSA. This is because a POSA would

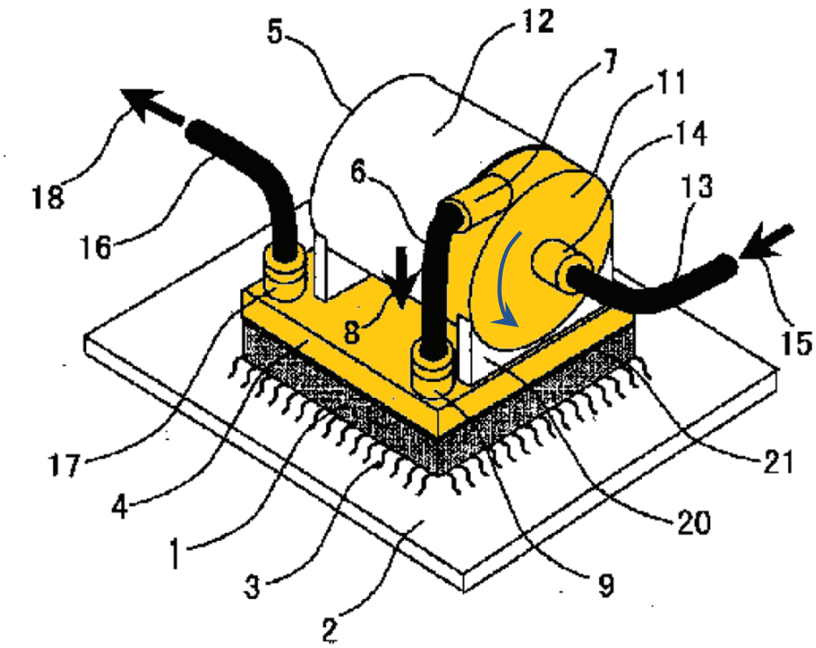
have been motivated to rotate the pump/impeller case of Shin's Figure 2 by 90 degrees to improve its thermal and hydraulic performance, as shown in the following two images.



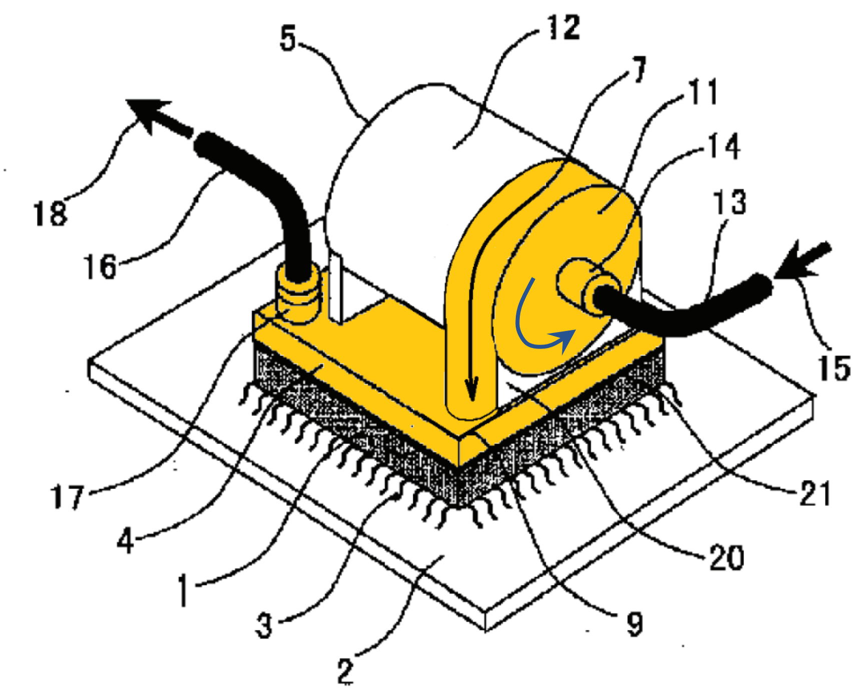
Shin's original orientation of pump 5/impeller case 11's coolant discharge section 7 (outlet), horizontal and separate from the water supply coupler 9 (inlet) of the heat sink 4



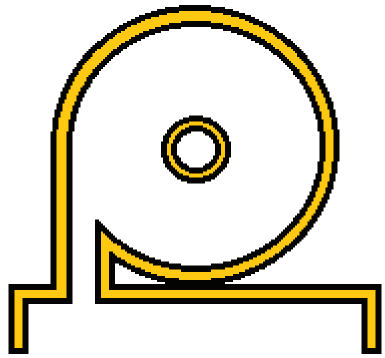
Shin's rotated orientation of pump 5/impeller case 11's coolant discharge section 7 (outlet), vertical and integrated with the water supply coupler 9 (inlet) of the heat sink 4



Shin's original orientation of pump 5/impeller case 11's coolant discharge section 7 (outlet), horizontal and separate from the water supply coupler 9 (inlet) of the heat sink 4



Shin's rotated orientation of pump 5/impeller case 11's coolant discharge section 7 (outlet), vertical and integrated with the water supply coupler 9 (inlet) of the heat sink 4
(another way to look at it)

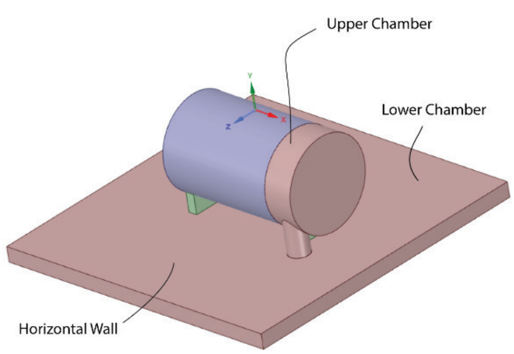


(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

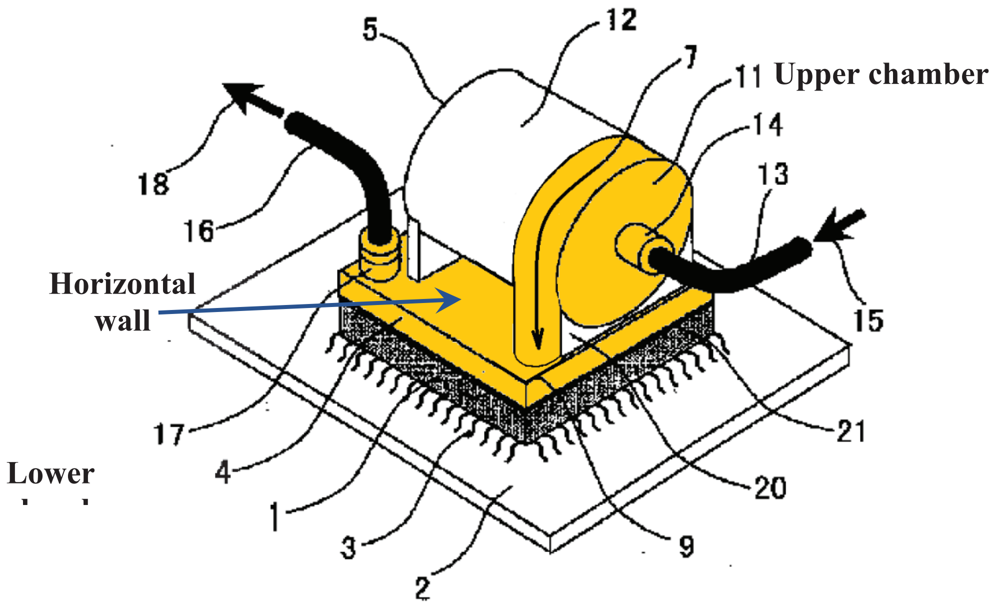
70. With such a simple rotation, a POSA would have understood that the upper chamber (the impeller case 11 of the pump 5) and lower chamber (the heat sink 4) of Shin can then be constructed integrally into a one-receptacle plastic structure using, for example, injection molding to include the claimed upper and lower chambers in a "single receptacle defining a fluid flow path," with the chambers still vertically spaced apart and separated by at least a horizontal wall, as shown above. The images above show the original and rotated orientation of the upper chamber of the two-chamber reservoir of Shin. In particular, after the rotation, the coolant discharge section 7, or the outlet, of the impeller case 11 of the pump 5 (i.e., the claimed upper chamber) can be integrated with the water supply coupler 9, or the inlet, of the heat sink 4 (i.e., the claimed lower chamber). That is, a POSA would have known how to and been motivated to modify Shin with this simple rotation to create a one-receptacle structure, i.e., a "reservoir" as stipulated to by the parties.

71. Rotating a cylindrical liquid pump as shown above would have been a trivial and routine exercise for a POSA. As an expert, who also satisfies the qualifications of a POSA, I have reoriented many, many pumps in my career by rotation. A POSA would have known that rotating a pump would lead to expected and successful results. Furthermore, a POSA would

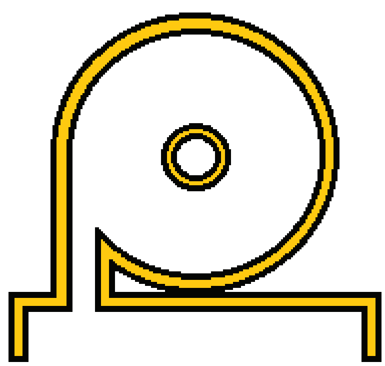
have been motivated to reorient the pump as shown above and below because such reorientation would eliminate the need for a connection tubing (hose 6) having two potential locations for leaks (the coupling between the coolant discharge section 7, i.e., the outlet of the pump 5/impeller case 11, and one end of the hose 6, and the coupling between the other end of the hose 6 and the water supply coupler 9, i.e., the inlet, of the heat sink 4). Additionally, directing the fluid from the upper chamber to the lower chamber directly inside a one-receptacle structure without going through separate tubing and couplings would improve heat transfer and performance of the system. It would also simplify the assembly and the system and reduces the number of components. The practice of reducing parts in a designed assembly is standard for engineers and follows the principles of Design For Manufacturability and Assembly (DFMA). A POSA would have known this and been motivated to practice this.



Shin – rotated with annotation



Shin – rotated with annotation 9 (another way to look at it)



(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

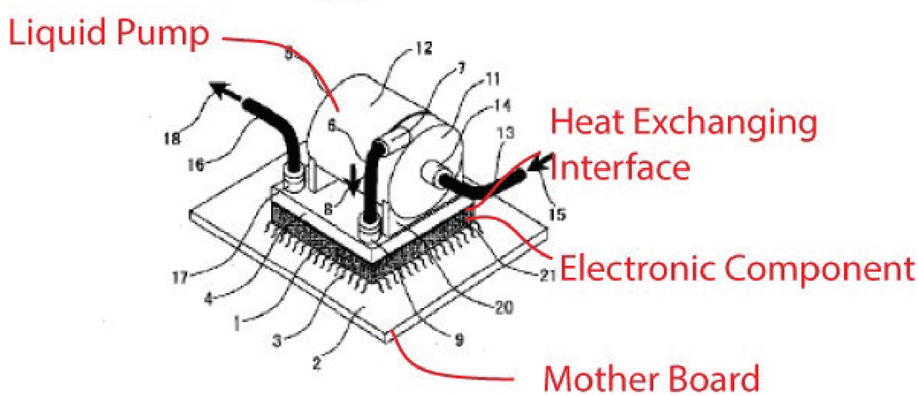
72. Now, the two-chamber "reservoir" of Shin, as modified, has an upper chamber and a lower chamber that are separate chambers that are vertically spaced apart and separated by a horizontal wall, as shown above. In sum, Shin discloses or teaches this limitation.

separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard …

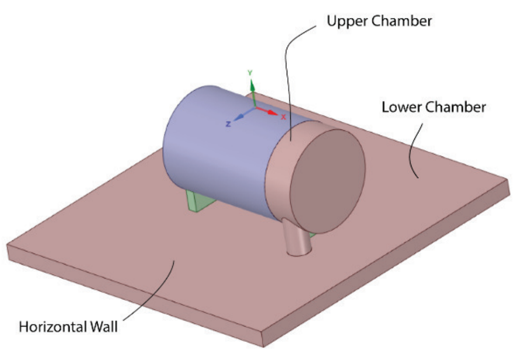
73. Shin's cooling system couples a heat exchanging interface of a reservoir in the modified Shin device as discussed above separably with electronic components positioned at a first

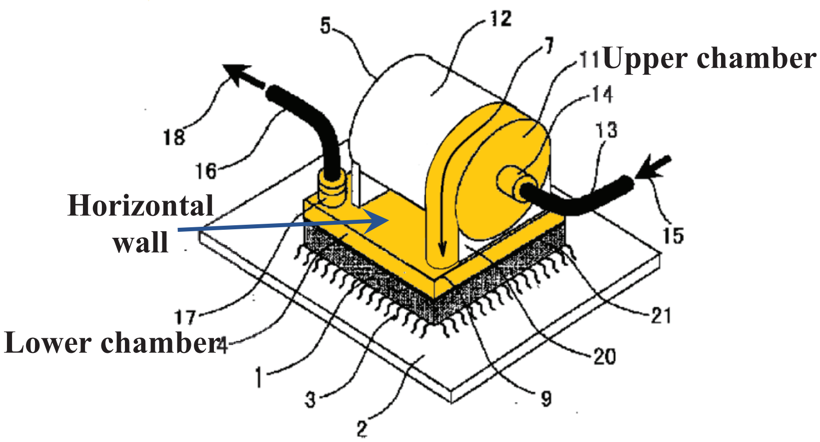
location on the motherboard. The coupling between the heat exchanging interface and the electronic component positioned on the motherboard is separable because a POSA would have known that such thermal coupling is accomplished by pressure and thermal grease or paste and is removable. The following images from Shin display liquid pumps, heat exchanging interfaces, electronic components, and motherboards.

FIG. 2

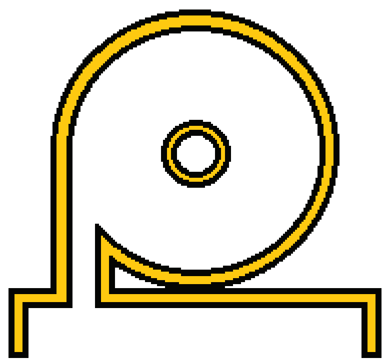


Shin Figure 2 (with the upper and lower chambers modified as follows)

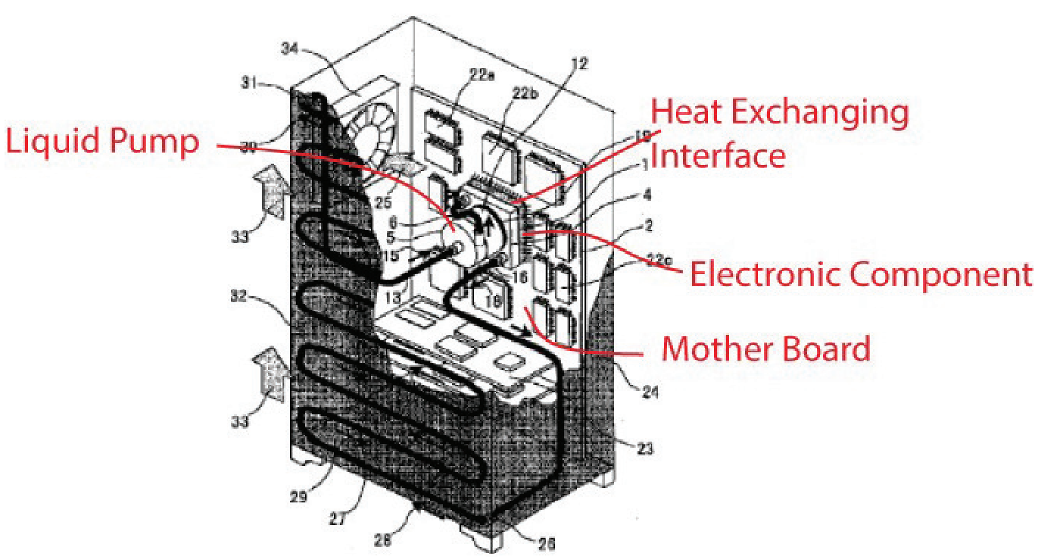




(See paragraphs 69-72 above)

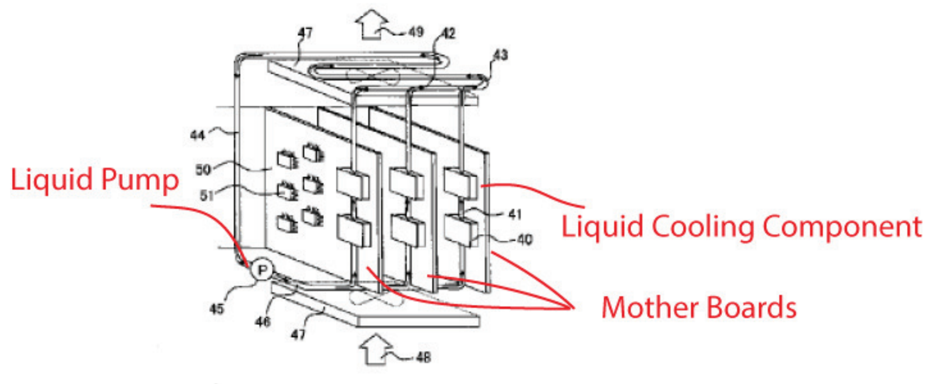


(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)



Shin Figure 3

FIG. 4



Shin Figure 4

74. Shin discloses the use of thermally conductive compound (21) that is used to ensure a separable thermal contact at the heat exchanging surface at the interface between the reservoir and the electronic component.

75. Shin also describes its heat exchanger as "in thermal contact" with the heat generating components, as seen in Claim 1:

> [Claim 1] A cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on said wiring board, a liquid cooled heat sink installed on said heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, characterized in that said pump is installed on the top part of said liquid cooled heat sink.

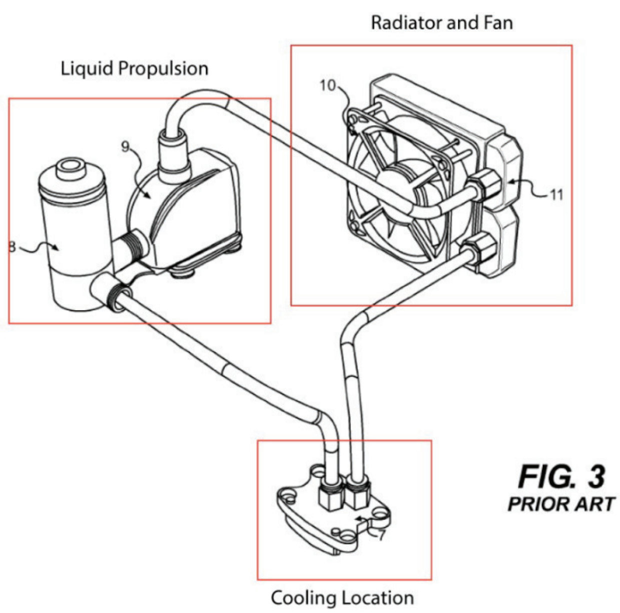
Shin Claim 1

76. Thermal contact is further discussed in Shin, as here:

[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin [0012]

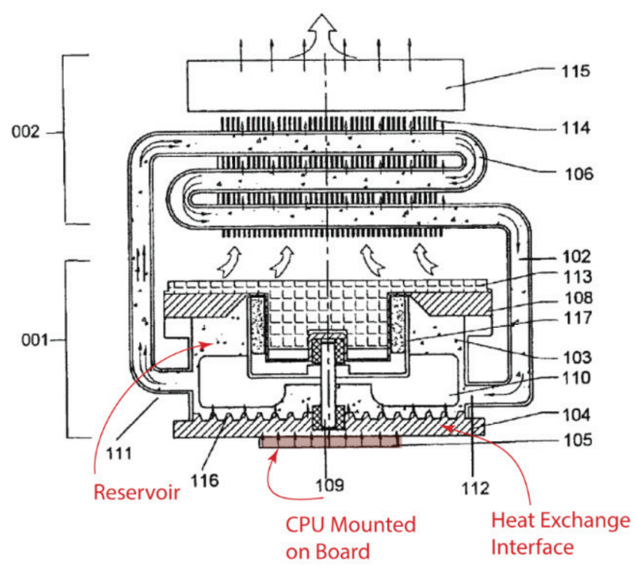
77. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. A POSA working on thermal management of computers and electronics routinely would implement heat exchanging interfaces that are separably coupled to electronic components on motherboards. This is shown in the following image, which was prior art in the asserted patents.



’362 patent, Figure 3

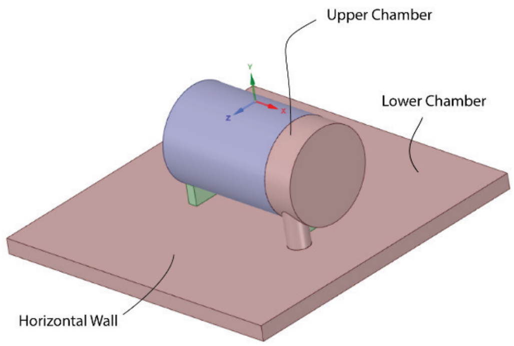
78. As an expert, who also satisfies the qualifications of a POSA, I have designed, used, and analyzed devices which are brought into separable thermal contact with heat-generating components. I also teach undergraduate and graduate students about thermal contact and its importance. A POSA would have been motivated to has a separable thermal coupling heat exchanging interface of a reservoir with an electronic component. Thermal coupling reduces the thermal resistance and lower temperatures of the electronic components. In addition, a separable connection simplifies assembly and replacement of parts upon failure.

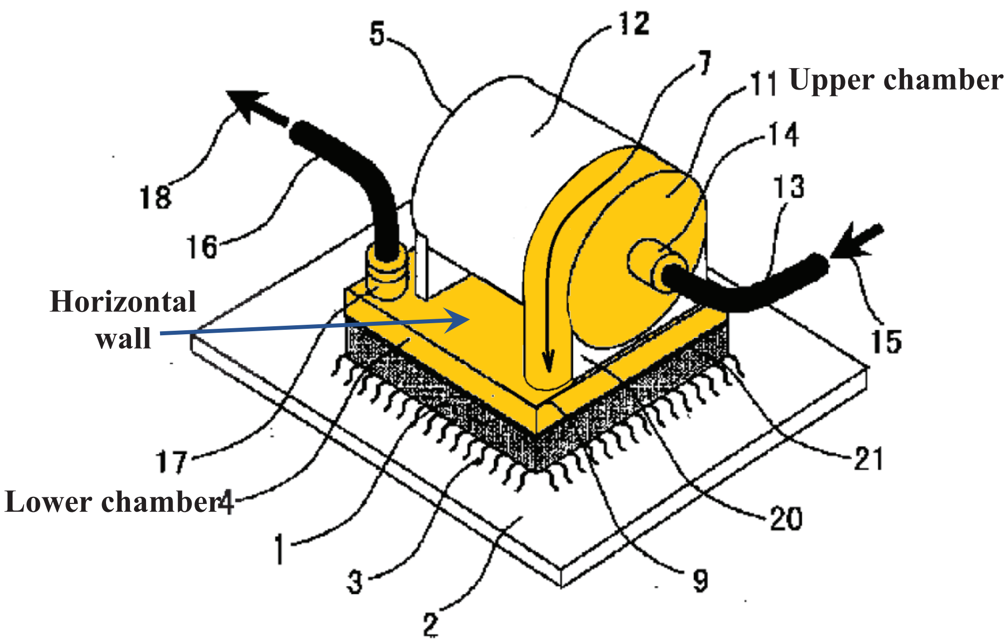
79. To the extent that this limitation was not disclosed or taught by Shin in view of the knowledge of a POSA, it was disclosed or taught by Wu. For instance, Wu discloses a separably thermally coupling a heat exchanging interface of a reservoir with an electronic component positioned on a motherboard; as discussed already and shown below.

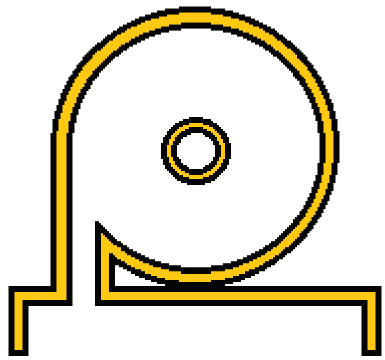


Wu, Figure 1

… the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

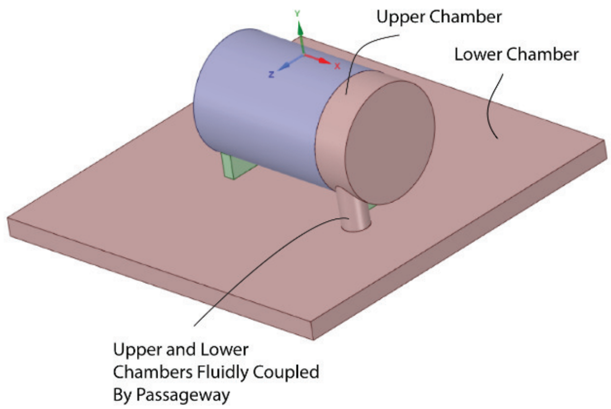


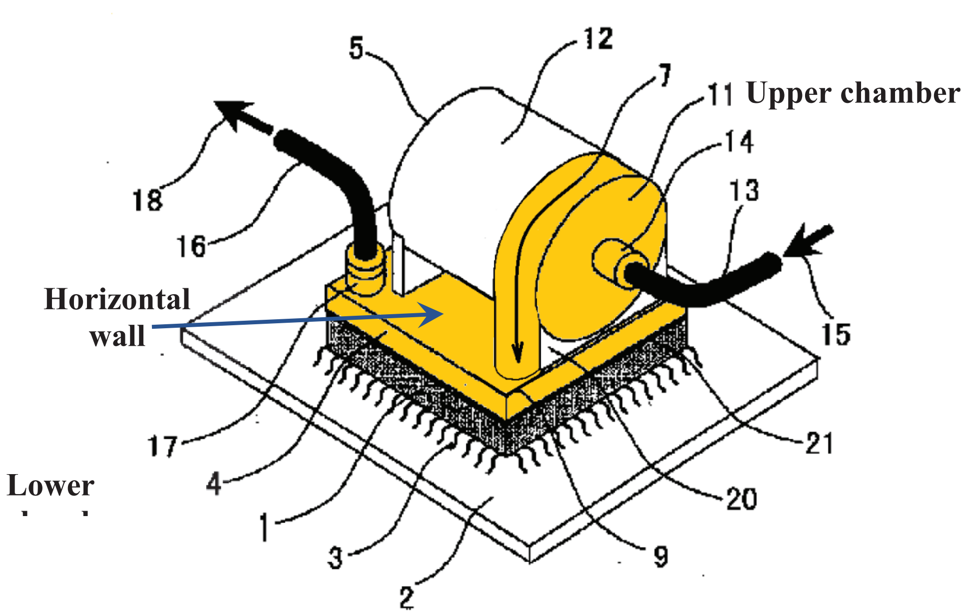


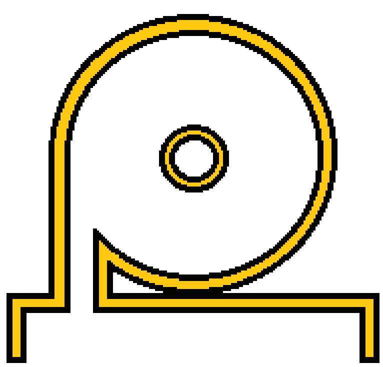


(Schematic of cross-sectional view of the single-receptacle “reservoir” of modified Shin)

80. As shown in the preceding images, the modified Shin system has an upper chamber and a lower chamber that are fluidly coupled by one or more passageways (e.g., one passage way 7 that is now integrated with both the upper chamber and the lower chamber) with the at least one passageway being positioned on the horizontal wall (e.g., the at least one passage way 7 that is now integrated with both the upper chamber and the lower chamber is also positioned on the horizontal wall). Furthermore, the heat exchange interface is removably coupled to the reservoir such that an inside surface of the heat exchange interface is exposed to the lower chamber of the reservoir, as explained below. In the image below, the heat exchanging surface is the bottommost surface of the lower chamber (heat sink 4); its inner side is exposed to the lower chamber of the reservoir.







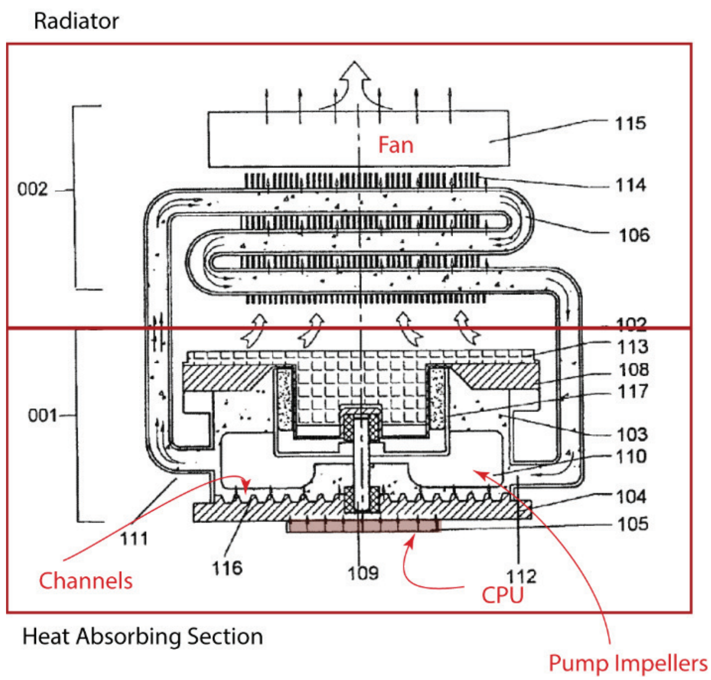
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

81. To the extent this was not disclosed or taught based on Shin, it would have been obvious to a POSA in view of her experience, education, and training. To couple two integrated fluid chambers by one or more passages between the chambers would have been evident and trivial for a POSA. Furthermore, a POSA would have known that a heat exchanging interface would be removably coupled to a fluid reservoir. I have worked with such systems multiple times in my own career. This coupling facilitates heat transfer by reducing thermal resistance; reducing thermal resistance is obvious to a POSA and is a standard topic taught to undergraduate students in engineering.

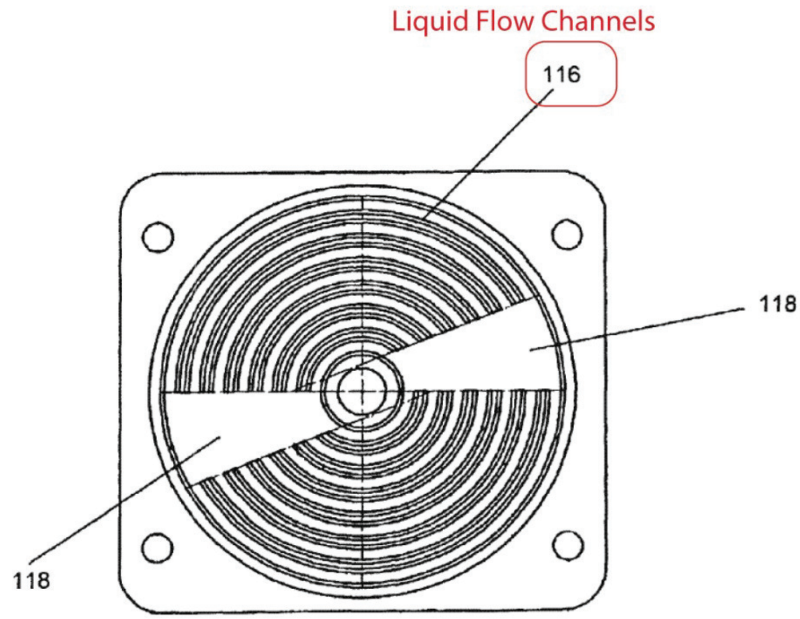
82. It would have been obvious to a POSA that the heat exchanging interface, though coupled to the lower chamber that is part of the single-receptacle reservoir, is removable at least during manufacturing of the cooling device. This is because the one-receptacle structure (i.e., the "reservoir") that includes both the upper chamber and the lower chamber in the modified Shin device must be open below for, e.g., the injection mold to form the lower chamber of the one-receptacle structure. As a result, the heat exchanging interface must be later installed at the bottom of the lower chamber via, for example, screws, for manufacturability reasons – that is, the heat exchanging interface is removably attached to the lower chamber of the reservoir. Further, the one-receptacle structure forming the single-receptacle reservoir is often made of plastic, while the heat exchanging interface is often made of copper. That is, the reservoir and the heat exchanging interface are often made of different materials, and a POSA would have known one easy way to couple them is using screws. A POSA would have known that obviously coupling accomplished by screws are typically removable. Also, since materials expand when their temperature increases, a POSA would have known that dissimilar materials, if rigidly connected, would

incur unwanted thermal stress, which makes it further obvious why the heat exchanging interface in the modified Shin device is removably coupled to the reservoir.

83. This limitation would have been further obvious based on Wu. Wu teaches a heat exchanging interface with heat exchanging surface removably coupled to the reservoir such that the inside surface of the heat exchanging interface is exposed to the reservoir.



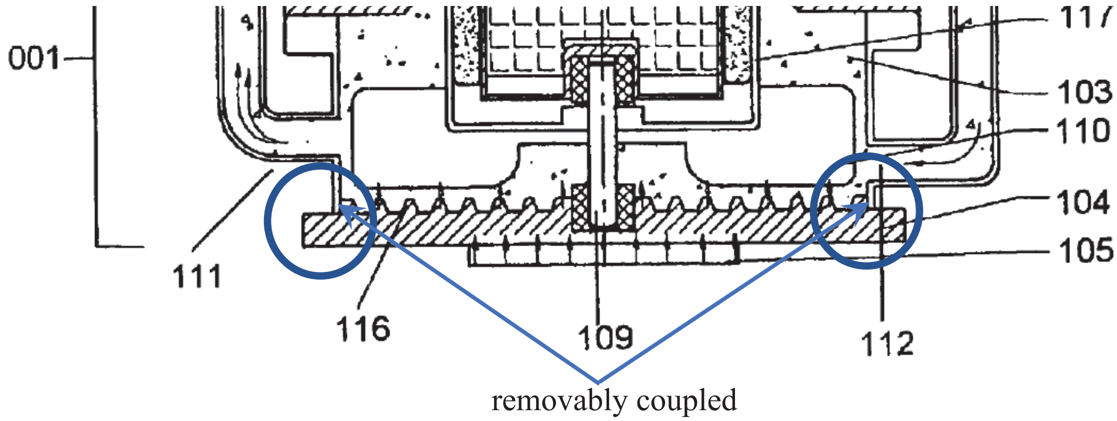
Wu, Figure 1



Wu Figure 3

84. Reading Wu's Figure 1 as shown below, a POSA also would have understood that the heat exchanging interface is removably coupled to the reservoir. This is because the heat exchanging interface in Wu is made of a different material than that of Wu's reservoir – the cross-hatching of the heat exchanging interface 104 is different from the empty inside representation of the reservoir's cross-section. A POSA would have understood this difference means the reservoir and the heat exchanging interface are made of different materials, with the reservoir often made of plastic and the heat exchanging interface often made of copper. As mentioned above, a POSA would have understood an easy way to couple them together is through the use of screws, which will create a removable coupling between them. Thus, a POSA would have known that the heat exchanging interface, although attached to the reservoir, is removable or detachable in Wu. In sum, a POSA would have been motivated to have an upper and lower chamber coupled by one or more

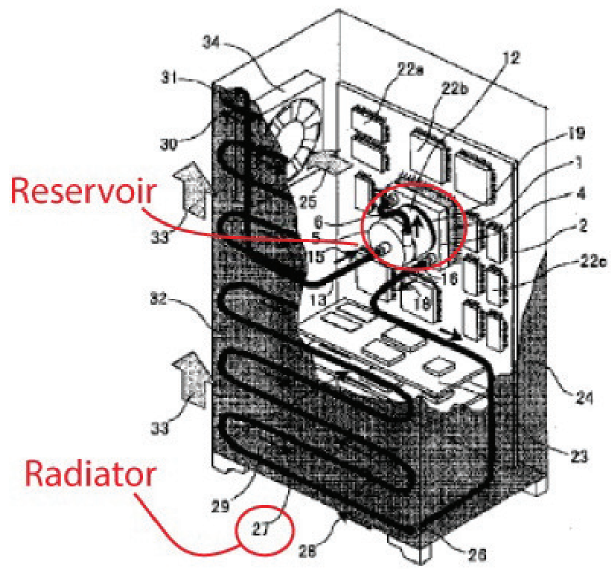
passages and with a heat exchanging removably coupled to the reservoir such that the inside surface of the heat exchanging surface is exposed to the lower chamber of the reservoir, as also disclosed or taught by Wu. Such a design effectively routes the cooling fluid to the heated region and reduces the thermal resistance presented by the heat exchanging surface.



Wu, Figure 1 (excerpt)

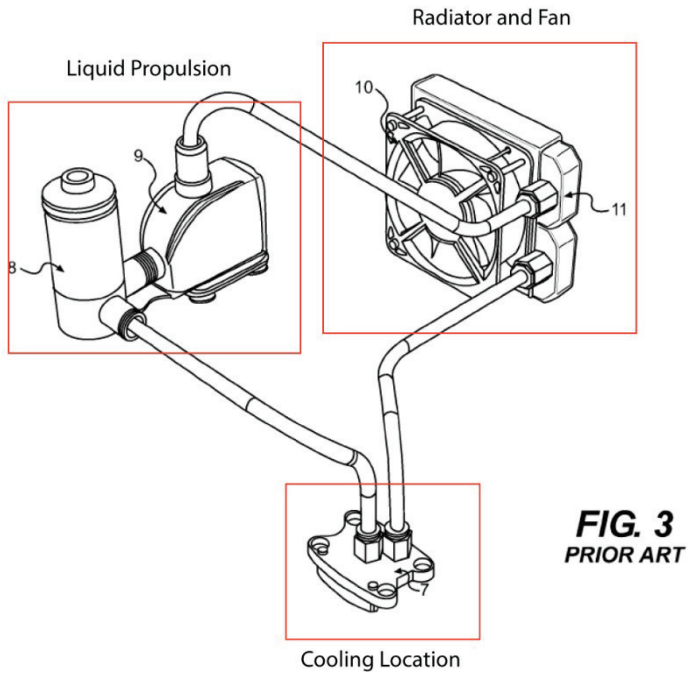
17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

85. Shin discloses a heat radiator at a second location horizontally spaced apart from the first location. The radiator and reservoir of Shin are fluidly coupled by tubing (26).



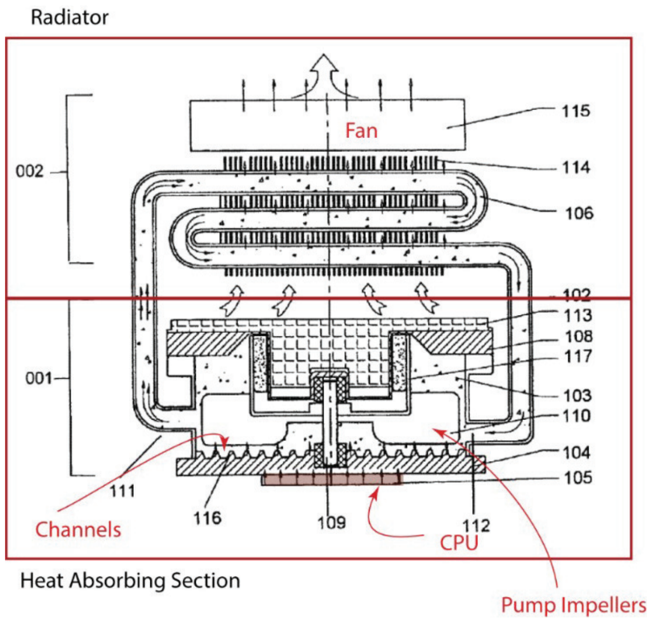
Shin Figure 4

86. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious based on the experience, education, and training of a POSA. A POSA would have understood that using a radiator is the standard means to extract heat from the liquid coolant. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems. This is supported by the following image, which was provided as prior art in the asserted patents.

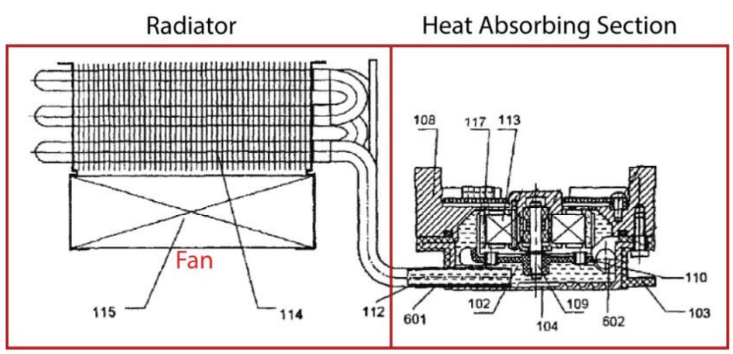


’362 patent, Figure 3

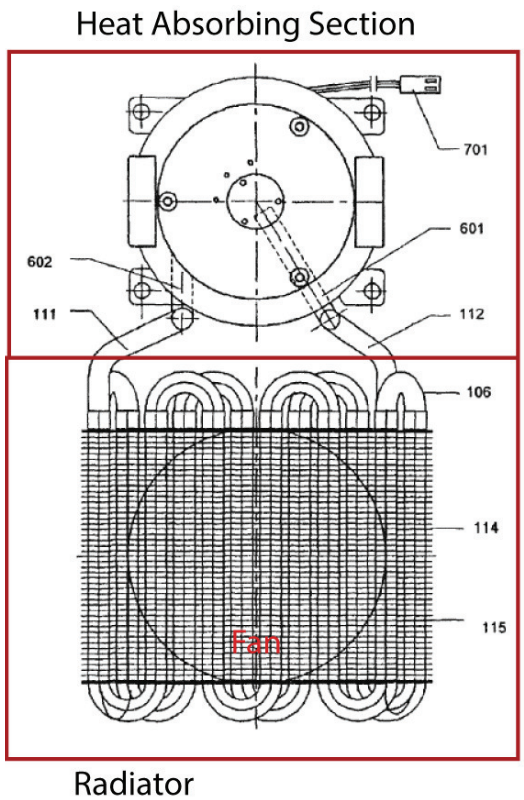
87. To the extent this was not disclosed or taught by Shin, it would have been obvious in view of Wu. For instance, Wu’s Figures 6 and 7, for example, teach a heat radiator at a second location that is horizontally spaced apart from the first location, the radiator and the reservoir being fluidly coupled by tubing that extends from the first location to the second location. A POSA would have been motivated to use a radiator positioned at a second location horizontally spaced apart from the first location and fluidly connected by tubing. Such an arrangement allows the heat to be transferred away from the electronic components and to the ambient environment. Horizontal tubing orientation, when possible, is often preferred because it minimizes pressure losses within a flow.



Wu, Figure 1



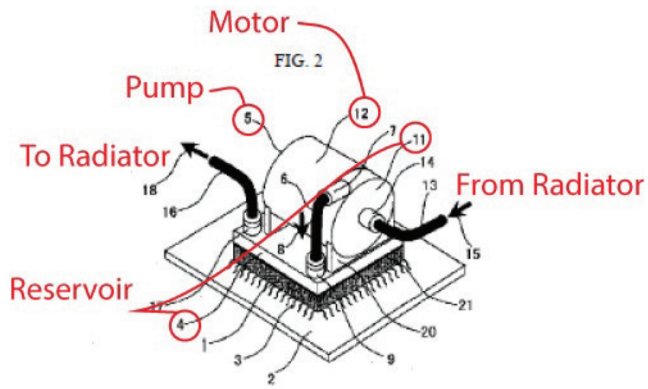
Wu, Figure 6



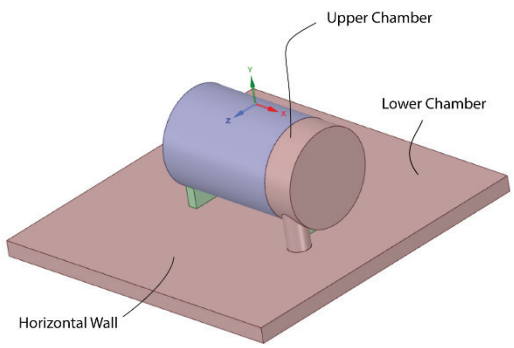
Wu, Figure 7

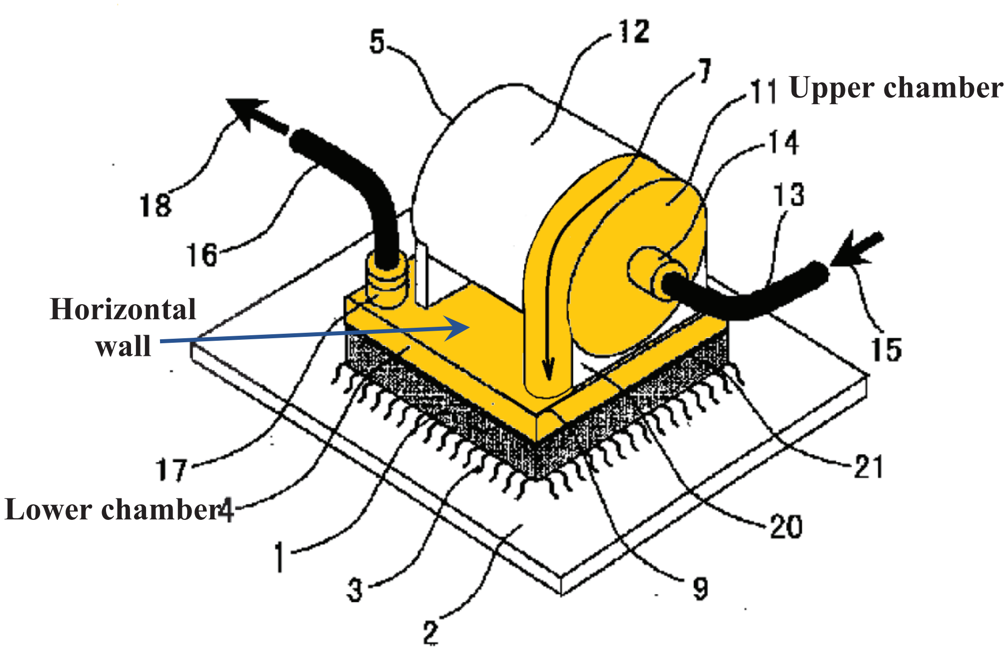
17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

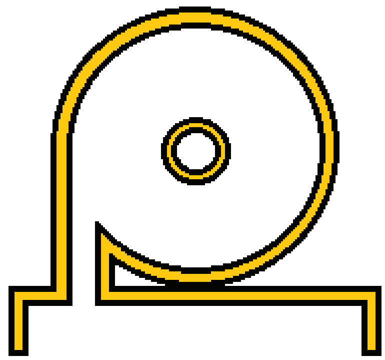
88. Shin discloses the claimed pump that circulates a cooling liquid through the reservoir and the heat radiator. Shin's pump (5) circulates the liquid through the reservoir and the heat radiator. The motor of the pump is identified as (12).



Shin Figure 2 (with the upper and lower chambers modified as follows)







(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

89. To the extent this limitation was not disclosed or taught in Shin, which, e.g., does not disclose or teach a curved blade expressly, it would have been obvious to a POSA based on her experience, education, and training. Using a pump to circulate a cooling liquid through a reservoir and a heat radiator with a motor and a curved-blade impeller that is positioned in the reservoir would have been routinely encountered by a POSA who worked on thermal management of electronics around the time of the claimed invention. In fact, I have worked with such systems many times in my research and teaching activities. A POSA would have been motivated to implement this in Shin because curved bladed impellers positioned in liquid reservoirs are common and simple means of providing liquid propulsion through the system. A POSA would have known that curved blades result in different thermal and fluid performance than straight blades. Further, a POSA would have known how to select between curved and straight blade systems. Due to the fluid dynamics of impellers, a POSA would have understood that curved blades often work better than straight blades in terms of efficiency.

90. To the extent this limitation was not disclosed or rendered obvious by Shin, it would have been obvious in view of Wu, which discloses or teaches this limitation.

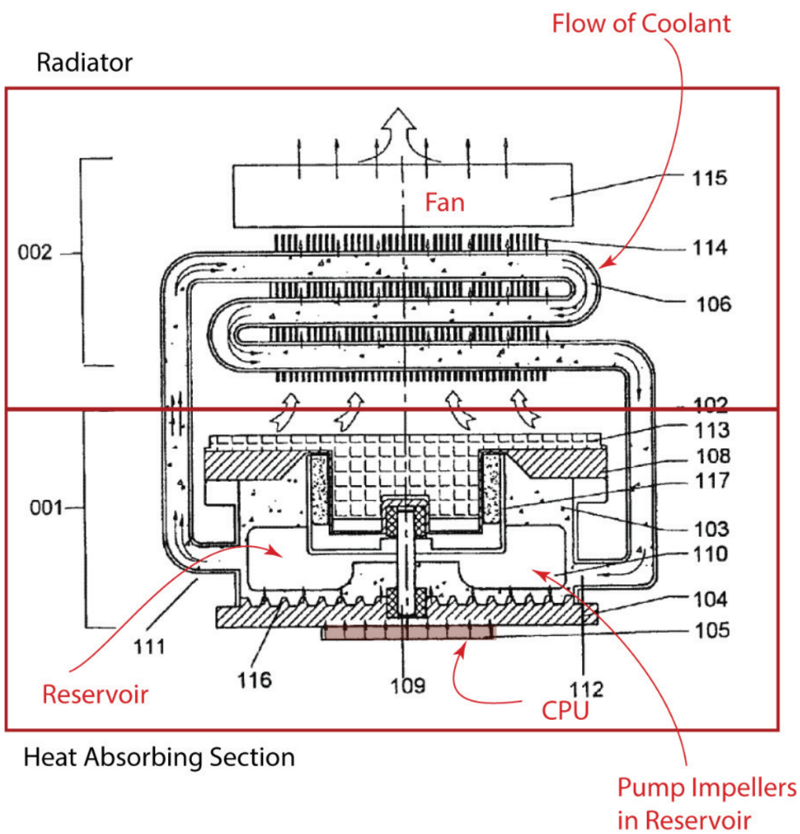
91. For instance, Wu discusses activating a pump to circulate cooling liquid through the reservoir and the heat radiator and a pump including a motor and an impeller having curved blades positioned in the reservoir.

FIG. **1** illustrates the cross-sectional view of one embodiment of the present invention. The cooling system **(101)** comprises a coolant **(102)** and an integrated radiation housing or section and absorption housing having a coolant storage unit **(103)** in absorption section, an absorption layer **(104)** between the coolant storage unit and the CPU **(105)** and a conduit **(106)**. The cooling system **(101)** is mounted on the top of the CPU with four fixing screws with the absorption layer in direct contact with the CPU as well as the coolant **(102)**. The cooling system **(101)** has the same power supply (not shown) as that of the CPU **(105)**, typically 12V DC, so when the CPU is in operation in which heat is generated, the cooling system **(101)** will be turned on. As shown in FIG. **1**, the absorption layer **(104)** is the base of the cooling system **(101)** and in order for the absorption layer **(104)** to absorb heat from the CPU quickly it is made of materials having a high heat conductivity such as bronze, copper (preferably red copper tube), aluminum and the like or alloys thereof. It will be appreciated that any thermally conductive material is contemplated. Further contemplated equivalents include mixtures of plastic and copper powder or the like. The other side of the absorption layer, the side that is in contact with the coolant, is made with a number of grooves **(116)** to increase the contact area between the coolant and the absorption layer so that more heat can be transferred about quickly. The absorption layer in the preferred embodiment has about 10 to 20 grooves and more preferably, about 10 to 15 grooves. The absorption layer

Wu Col. 4, lines 10-37

Another embodiment is directed to the process of cooling. More specifically, the CPU (**105**) triggers the cooling system (**101**) when it is in operation and generates heat. The absorption layer of the cooling system absorbs the heat generated by the CPU as they are in contact or direct contact. The coolant (**102**) in the coolant storage unit (**103**) in turn absorbs the heat from the absorption layer. At the same time,

Wu, Column 3, lines 47-54



Wu, Figure 1

92. Wu discloses or teaches curved impeller blades, as shown here ("bent" blades):

least one blade. The impeller (**110**) is designed with the bottom part, thereof constitutes about one-third of the blade, slightly bent at an angle towards the direction of rotation making it a shape of an arc. This special design enhances the heat transfer process by creating a lifting force for the coolant at the bottom part of the coolant storage unit. It is

Wu, Col. 5, lines 16-21

As other examples, in Wu, Claims 9 and 16 recite "bent" blades (see below):

9. The cooling system of claim **1** wherein the impeller further comprises an axis and at least one blade having

one-third of the bottom part slightly bent at an angle towards the direction of rotation making it a shape of an arc to enhance the heat transfer process by creating a lifting force for the coolant at the bottom part of the coolant storage unit.

16. An improved cooling system designed for an electronic component comprising:

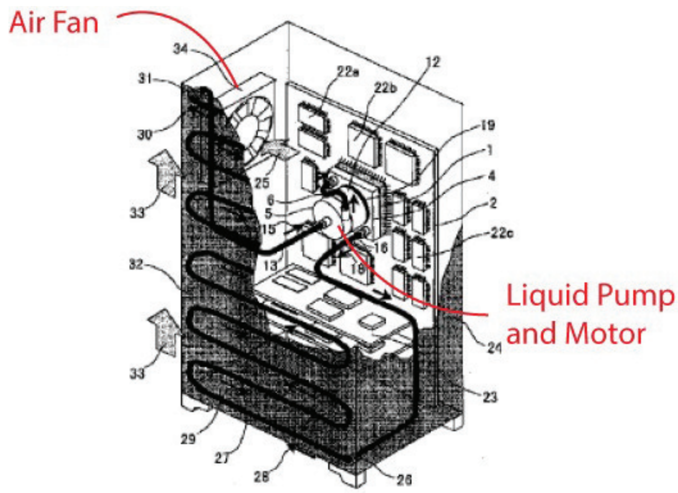
(a) a coolant; and

(b) an integrated unit comprising: (i) an absorption housing having a coolant storage unit, the coolant storage unit having a cover for preventing leakage of coolant from the coolant storage unit; (ii) a radiation housing having a plurality of radiation sheets; (iii) an absorption layer between the coolant storage unit and the electronic component; and (iv) a circulation generation unit having a brushless DC motor, a motor stator, a rotor, and a rotatable impeller which causes the coolant to flow from the coolant storage unit to the radiation housing and back to the coolant storage unit through a conduit; wherein the impeller includes at least one blade in which a bottom portion of the at least one blade

is slightly bent at an angle towards the direction of rotation of the impeller.

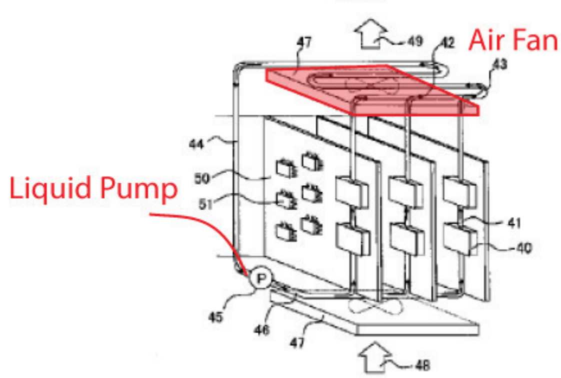
17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

93. The system of Shin activates a fan to direct air through the heat radiator with the fan operated by a motor separate from the pump. The separate air fan and liquid pump are demonstrated in the following two images from Shin.



Shin Figure 3

FIG. 4



Shin Figure 4

94. To the extent this was not disclosed or taught from Shin alone, it would have been obvious to a POSA based on her experience, education, and training. Fans are ubiquitous in their

use directing air through heat radiators. Often air fans are operated with a motor separate for the motor of the liquid pump. A POSA would have been motivated to use a separate motor because air fans are typically purchased with their own locomotive system. Furthermore, separate motors allow the air fan and the liquid pump to be controlled separately based on the heating requirements of the system. This allows impeller speeds to be modulated independently, reducing noise and wasted energy. Furthermore, separate motors provide, a safety measure – if one motor fails the other motor will continue to operate and provide cooling. This opinion of mine is supported by the prior art listed in the asserted patents, as shown here. In addition, the torque requirements for an air fan and a liquid pump tend to be very different and would have preferably been driven by different motors generating different torques from a POSA's perspective. These factors would have motivated a POSA to use two different motors.

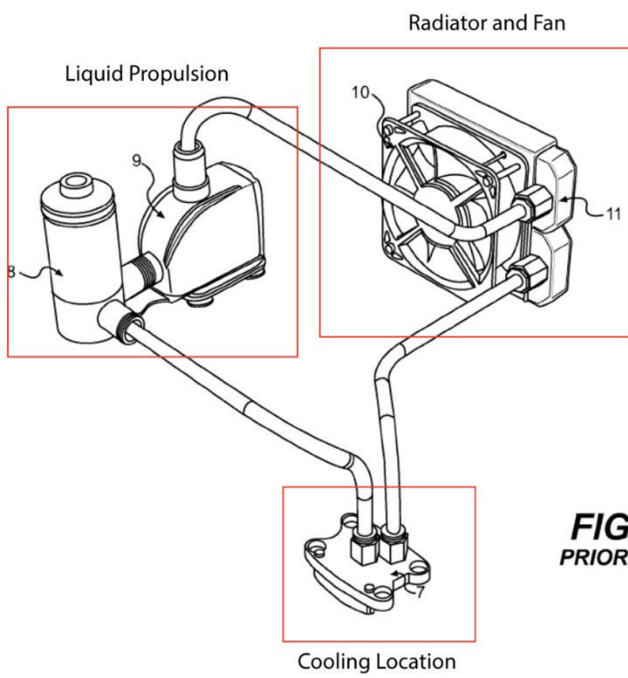
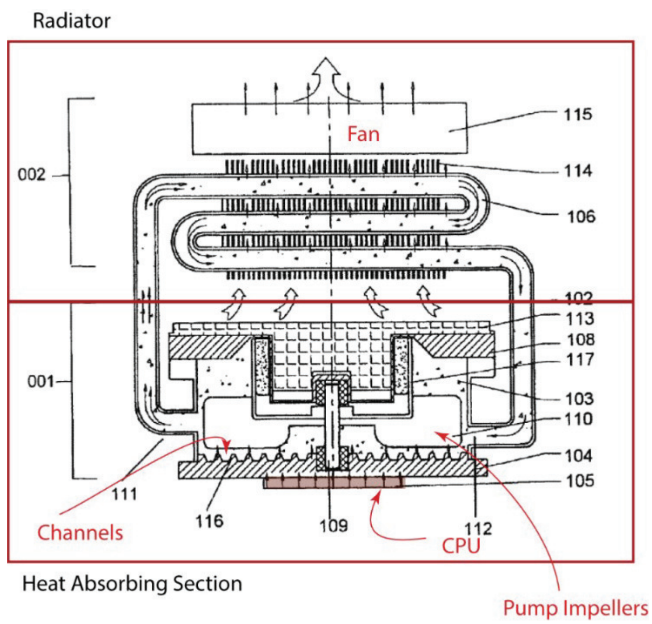


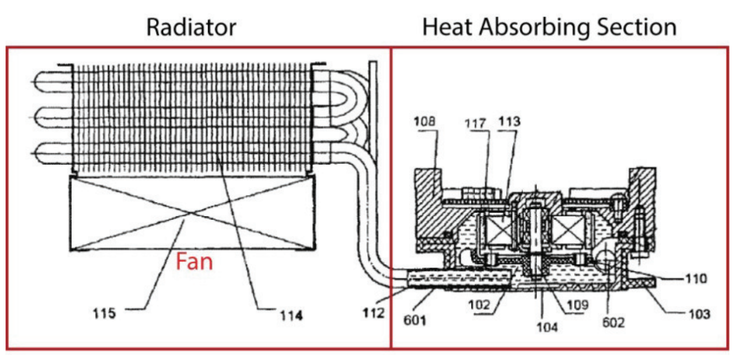
FIG. 3
PRIOR ART

'362 patent, Figure 3

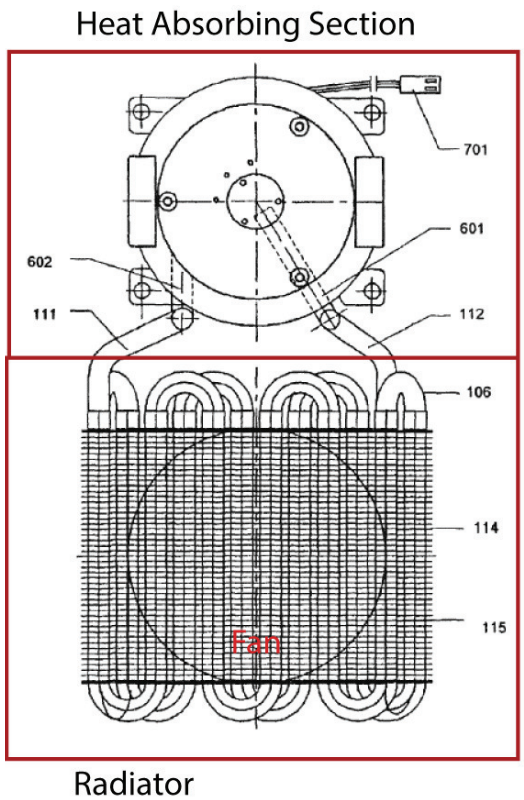
95. To the extent this was not disclosed or taught from Shin, it would have been obvious with the knowledge of a POSA and/or in light of Wu. Wu teaches a fan/blower 115 that is separate and distinct from pump motor 113 (Wu 3:21-23; 3:39-46; 3:57-60; 5:60-64; 7:4-5; Claim 10 as examples; see also Figures 1, 6, and 7).



Wu, Figure 1



Wu, Figure 6

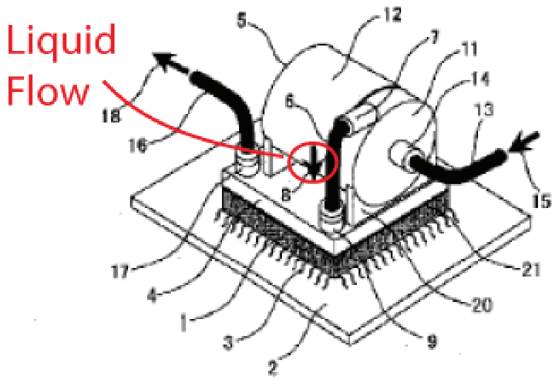


Wu, Figure 7

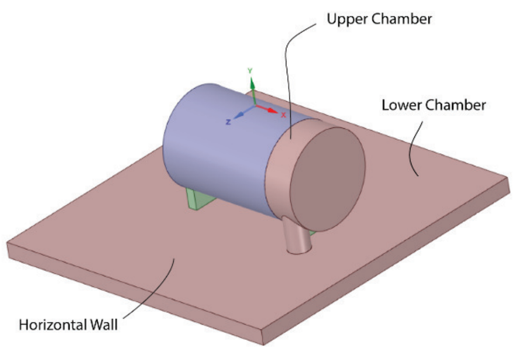
Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

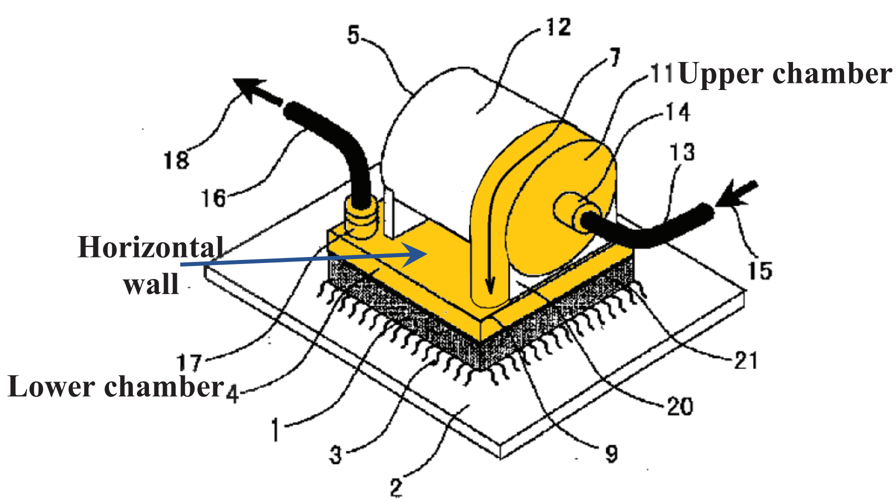
96. Claim 18 is a claim that asserted claim 19 depends from so I will include an analysis of claim 18 here. Shin discloses a pump that circulates liquid between the upper and lower chambers of the reservoir, as shown here. A POSA would have been motivated to use a pump that circulates cooling liquid between and upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.

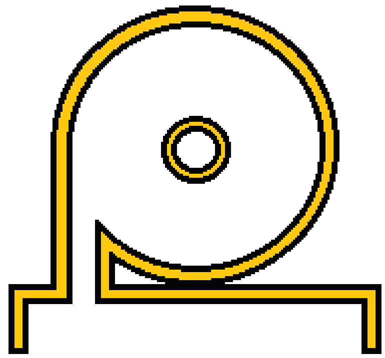
FIG. 2



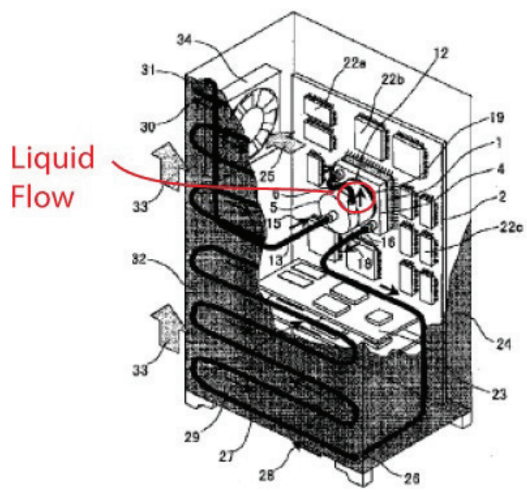
Shin Figure 2 (with the upper and lower chambers modified as follows)





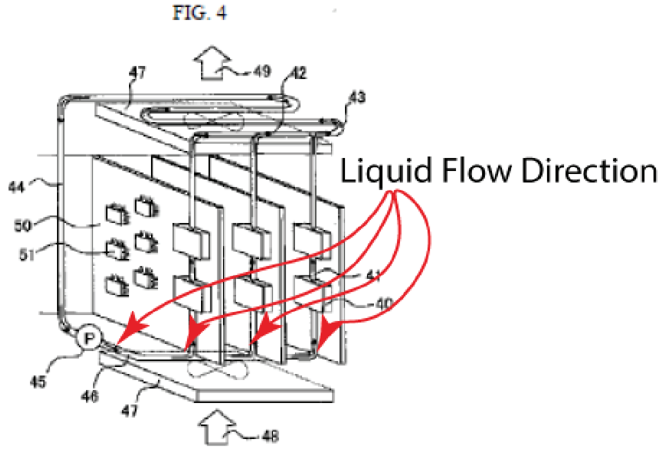


(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)



Shin Figure 3

FIG. 4



Shin Figure 4

The liquid pump motor 12 of Shin is activated and powered by a DC power supply, as discussed here:

[0019] The motor 12 is a DC motor driven by a direct current power supply. Using a DC motor allows the motor speed to be easily changed by changing the DC voltage, thus enabling control of cooling power. Moreover, making the motor into a DC brushless motor makes it possible to implement a pump of low noise and long service life.

Shin Paragraph 19

[0020] If the flow rate of liquid coolant is relatively low, on the order of 0.1 (liters/minute), making the drive voltage such that it can be driven by dry cells of, for example, about 1 to 1.5 (V), allows for battery driving of the pump, making it possible to create a liquid cooling system of high reliability. Furthermore, if the flow rate of liquid coolant is relatively high, on the order of 1 (liter/minute), making the drive voltage into a voltage of about 2 to 12 (V), which can be supplied by the DC power supply of electronic equipment,

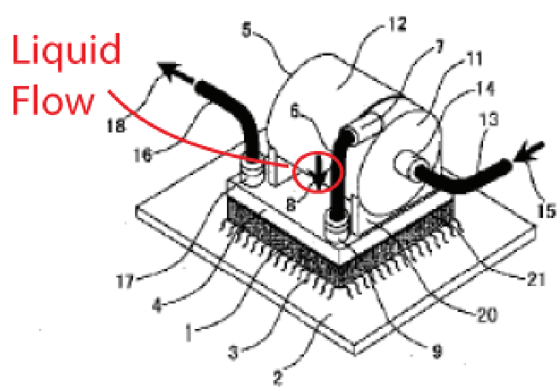
makes it possible to create a compact and inexpensive liquid cooling system, because there is no need to provide a dedicated power supply for the pump. However, the present invention does not necessarily limit the motor 12 to a DC motor, and an AC motor driven by alternating current of, for example, 100 (V) or 200 (V) may be used as well.

Shin Paragraph 20

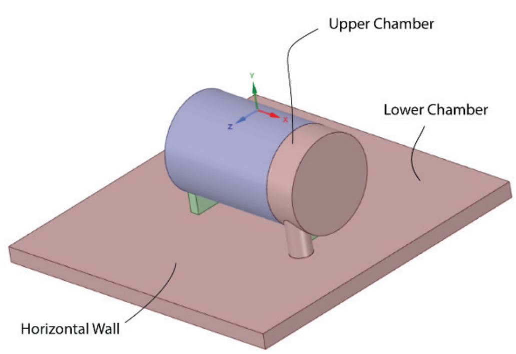
Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

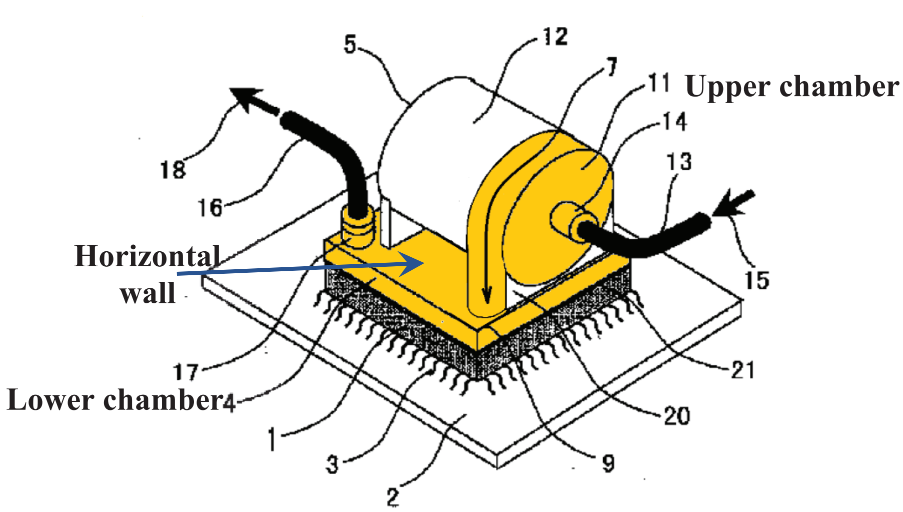
97. As already discussed for Claim 17, Shin discloses the circulating of a cooling liquid between and upper and lower chamber that includes passing the cooling liquid from the upper chamber to the lower chamber through a single passage of the one or more passageways. I adopt that earlier discussion here.

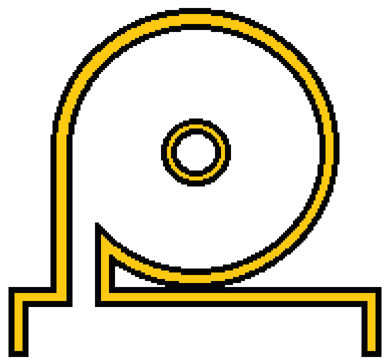
FIG. 2



Shin Figure 2 (with the upper and lower chambers modified as follows)







(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

98. To the extent this claim is not evident based on Shin alone, it would have been obvious in view of the experience, education, and training of a POSA. A POSA would have known how to circulate cooling liquid between upper and lower chambers of a reservoir through a single passageway. A POSA working with liquid pumps and thermal management of electronics would have found the implementation of such a fluid circulation strategy to be simple and routine. A POSA would have been motivated to circulate liquid between an upper and lower chambers because this facilitates fluid to be brought into proximity to the CPU or heat-generating device.

B. Ground 2 – Shin in View of Batchelder

99. It is my opinion that Shin, in view of Batchelder and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

100. As I have already discussed, the preamble of Claim 17 was disclosed or taught by Shin either alone or in view of the experience, education, and training of a POSA; I adopt that prior analysis in Ground 1 here.

101. To the extent this preamble was not disclosed or taught by Shin alone, it would have been obvious in view of the knowledge of a POSA or Batchelder. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics.

102. For example, in the abstract, Batchelder discusses its use in cooling electronics using a liquid cooling system.

SUMMARY OF THE INVENTION

The primary objective of this invention is to provide a low cost high reliability heat exchange apparatus that incorporates a composite substrate containing flow channels and a heat transfer fluid, providing low thermal resistance cooling to high density heat sources.

A further objective of this invention is to provide a design for cooling electronic components that is compatible with the geometry and manufacturing tooling associated with the passive spreader plate heat sinks currently in general use.

A further objective of this invention is to provide an active spreader plate with no moving or rotary mechanical seals.

A further objective of this invention is to provide a heat sink design for electronic components that uses a single motor to impel atmospheric motion and the motion of an additional heat transfer fluid.

A further objective of this invention is to provide an active spreader plate without hoses or fluid couplings.

Batchelder Col. 2, lines 39-57.

103. Batchelder further discusses cooling computer electronic components at 2:29-35; 5:64-67; and 6:1-5; as examples. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

104. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified); I adopt that prior analysis in Ground 1 here.

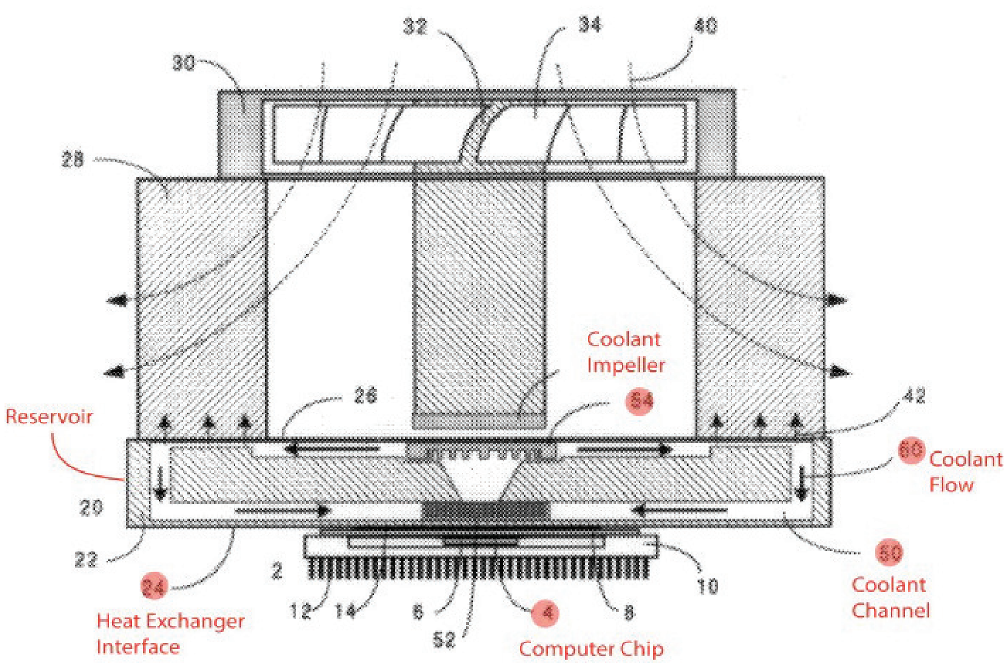
105. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. A POSA working on thermal management of computers and electronics routinely would implement heat

exchanging interfaces that are coupled to electronic components on motherboards. I have used such systems multiple times in my own work and I teach both undergraduate and graduate students on such systems.

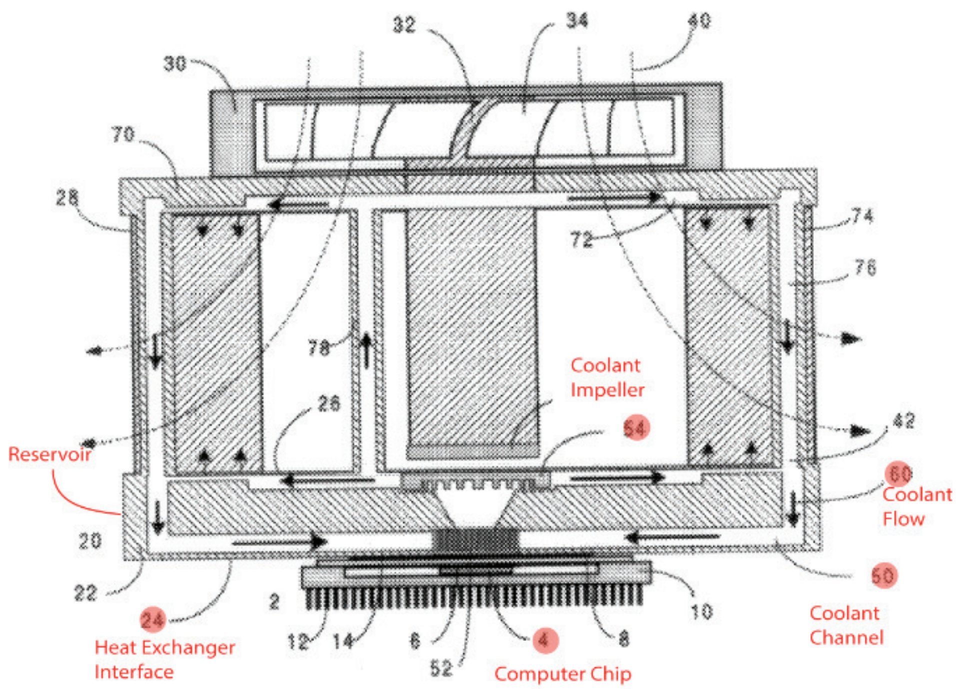
106. This limitation is also obvious in view of Batchelder as evident by the following passage and images. A POSA would have been motivated to incorporate a separably heat exchange surface with an electronic component because this promotes excellent heat transfer from the heat generating device.

> FIG. 7 shows an assembly of a heat sink containing an active spreader plate. A heat source (2) is attached to the bottom sheet (202) of the active spreader plate assembly through a compliant insulating layer (14). If the heat source

Batchelder, Col. 7 lines 23-26



Batchelder, Figure 2



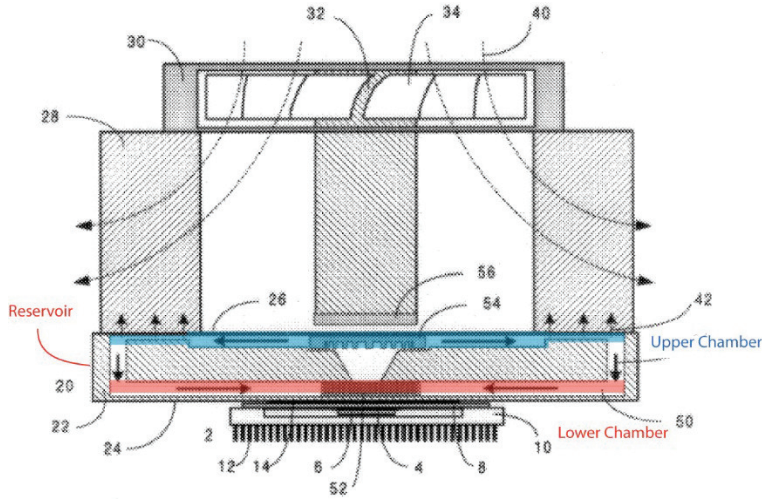
Batchelder, Figure 5

… the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

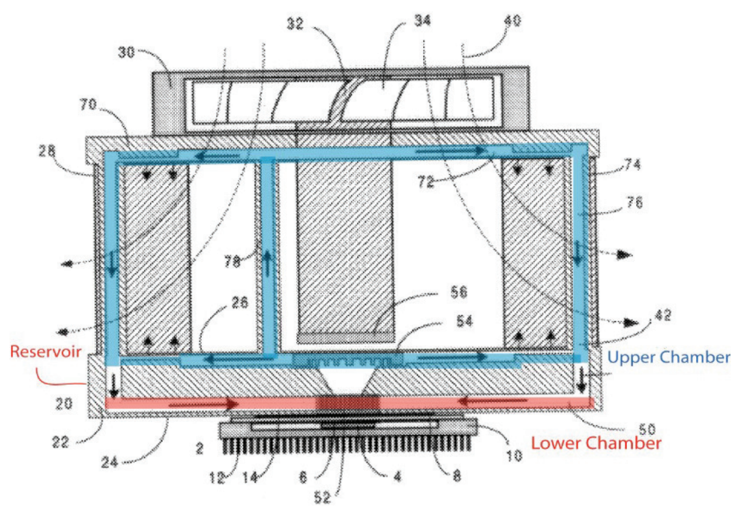
107. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified) either alone or in view of the knowledge of a POSA; I adopt that prior analysis in Ground 1 here.

108. This limitation would also have been obvious to a POSA in view of Batchelder. For example, Batchelder discloses a reservoir that includes upper and lower chambers that are vertically spaced apart and separated by at least a horizontal wall, as shown below. A POSA would have been motivated to incorporate a reservoir with an upper and lower chamber vertically spaced apart and separated by a horizontal wall. The use of separate

upper and lower chambers is an efficient way to route fluid from a pump to the location where heat transfer occurs.



Batchelder, Figure 2



Batchelder, Figure 5

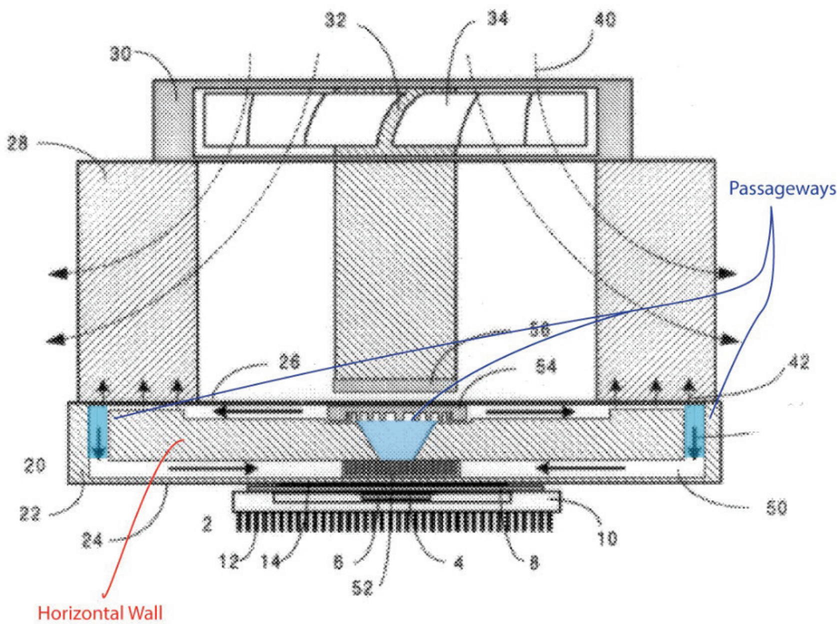
… the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

109. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified) alone or in view of the knowledge of a POSA; I adopt that prior analysis here.

110. To the extent this was not disclosed or taught based on Shin, it would have been obvious to a POSA in view of her experience, education, and training. To couple two fluid chambers by one or more passages would have been evident and trivial for a POSA. Furthermore, a POSA would have known that a heat exchanging interface would be removably coupled to a fluid reservoir. This coupling facilities heat transfer by reducing thermal resistance; reducing thermal resistance is obvious to a POSA and is a standard topic taught to undergraduate students in engineering. I have worked with heat exchanging interfaces that are removably coupled to the reservoirs in my own research, multiple times. I have also worked with multiple chambers that are fluidly coupled by one or more passageways multiple times.

111. As I have already discussed, the "removably coupled" limitation of Claim 17 is rendered obvious by Shin alone or in view of the knowledge of a POSA; I adopt that prior analysis in Ground 1 here.

112. This limitation is further obvious in view of Batchelder. For example, in the following image from Batchelder, there is an upper and a lower chamber of a reservoir. The chambers are separated by a horizontal wall and there are one or more passageways positioned on the horizontal wall that fluidly couple the two chambers.



Batchelder, Figure 2

113. Batchelder also discloses or teaches that its heat exchanging interface is removably coupled to the reservoir, as shown below. This is because the bottom sheet (202) and the lower stamped plate (204) are made of different materials, and a POSA would have known that they are removably coupled to each other. A POSA would have been motivated to have an upper and lower chamber coupled by one or more passages and with a heat exchanging removably coupled to the reservoir such that the inside surface of the heat exchanging surface is exposed to the lower chamber of the reservoir. Such a design effectively routes cooling fluid to the heated region and reduces the thermal resistance presented by the heat exchanging surface.

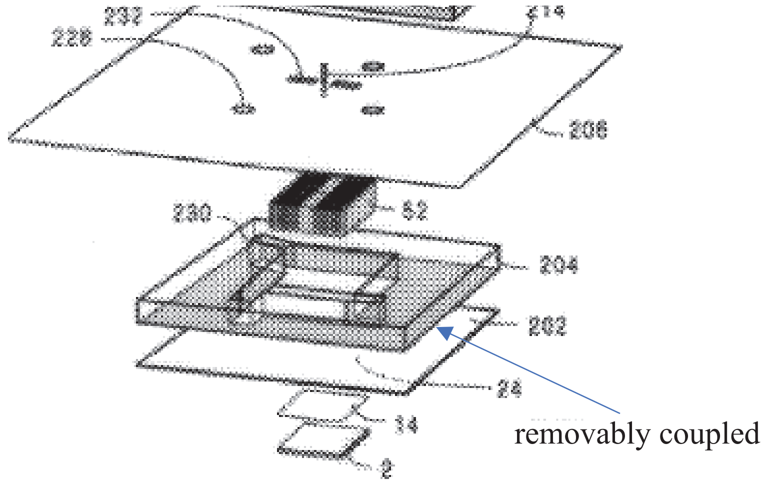


FIG.7

medial sheet (**206**). The bottom sheet (**202**) and fin means (**52**) are preferably metallic. The lower stamped plate (**204**), the medial sheet (**206**), the upper stamped plate (**204**), the channel forming sheet (**210**), and the top sheet (**212**) are preferably formed from plastic. Fin means (**28**) attaches to

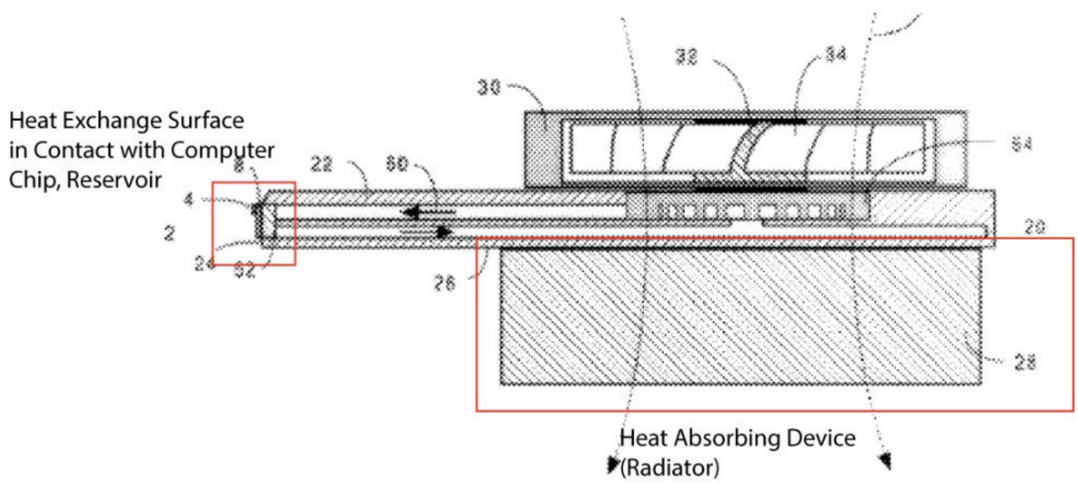
Batchelder 7:51-55

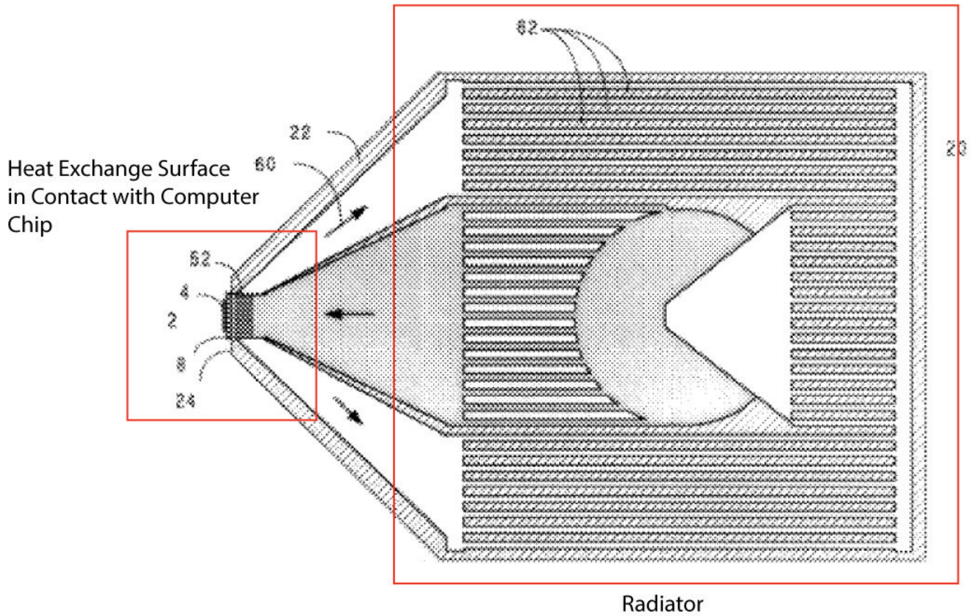
17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

114. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin; I adopt that prior analysis in Ground 1 here.

115. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious based on the experience education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems.

116. To the extent this limitation was not disclosed or taught based on Shin in view of the knowledge, education, experience, and training of a POSA, it would have been obvious in view of Batchelder, as shown below. A POSA would have been motivated to use a radiator positioned at a second location horizontally spaced apart from the first location and fluidly connected by tubing. Such an arrangement allows the heat to be transferred away from the electronic components and to the ambient environment. Horizontal tubing, when possible, is often preferred because it minimizes pressure losses within a flow.





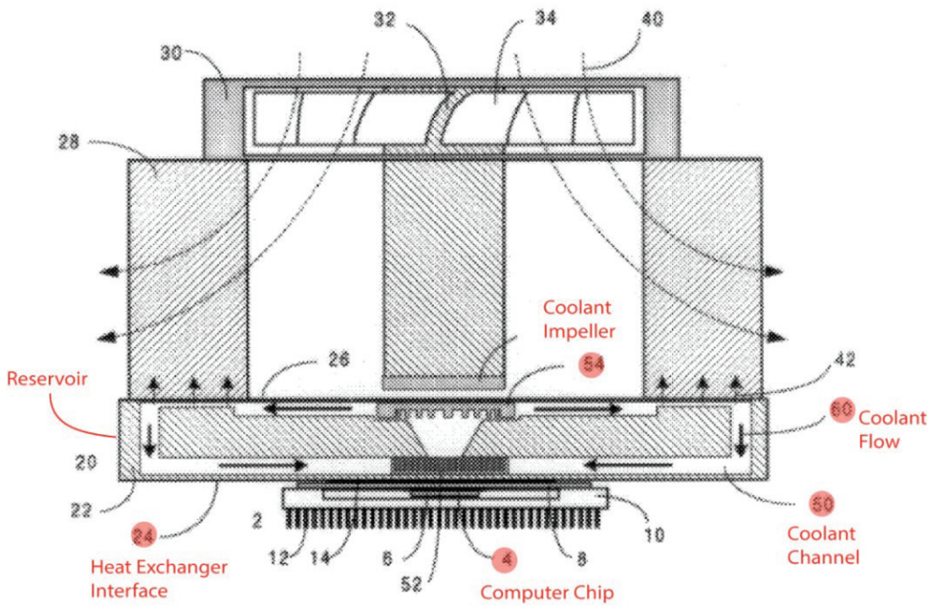
Batchelder, Figure 4

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

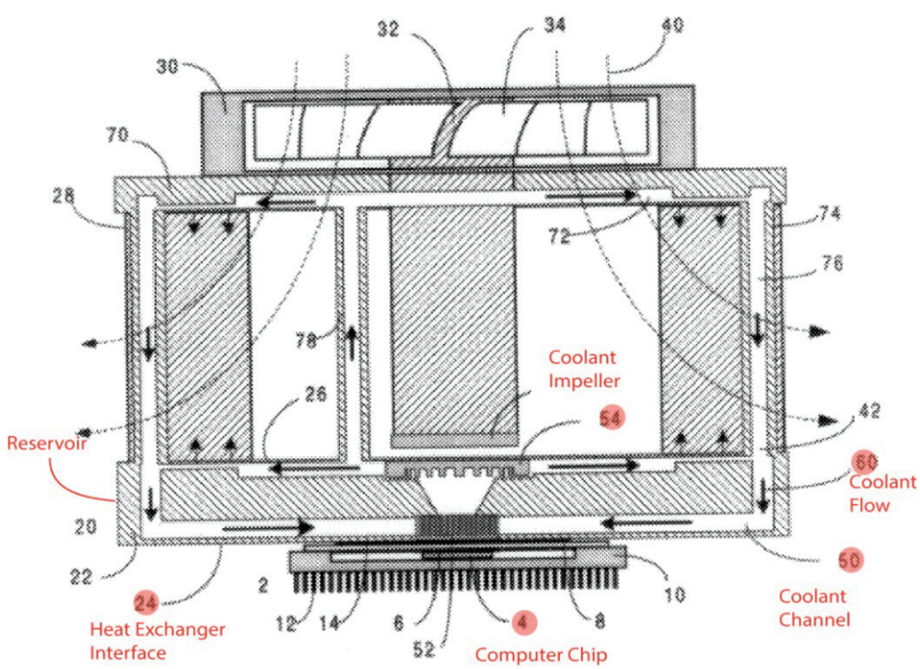
117. As I have already discussed, this portion of Claim 17 was disclosed or taught by Shin (as modified) (except for the curved blades); I adopt that prior analysis in Ground 1 here.

118. To the extent this limitation was not disclosed or taught in Shin, it would have been obvious to a POSA based on her experience, education, and training. Using a pump to circulate a cooling liquid through a reservoir and a heat radiator with a motor and a curved-blade impeller that is positioned in the reservoir is routinely encountered by a POSA who works on thermal management of electronics. In fact, I have worked with such systems many times in my research and teaching activities.

119. To the extent this limitation was not disclosed or taught in view of a POSA's experience, education, and training, it would have been obvious in view of Batchelder, which shows a pump that has an impeller that is positioned in the reservoir (see following figures).

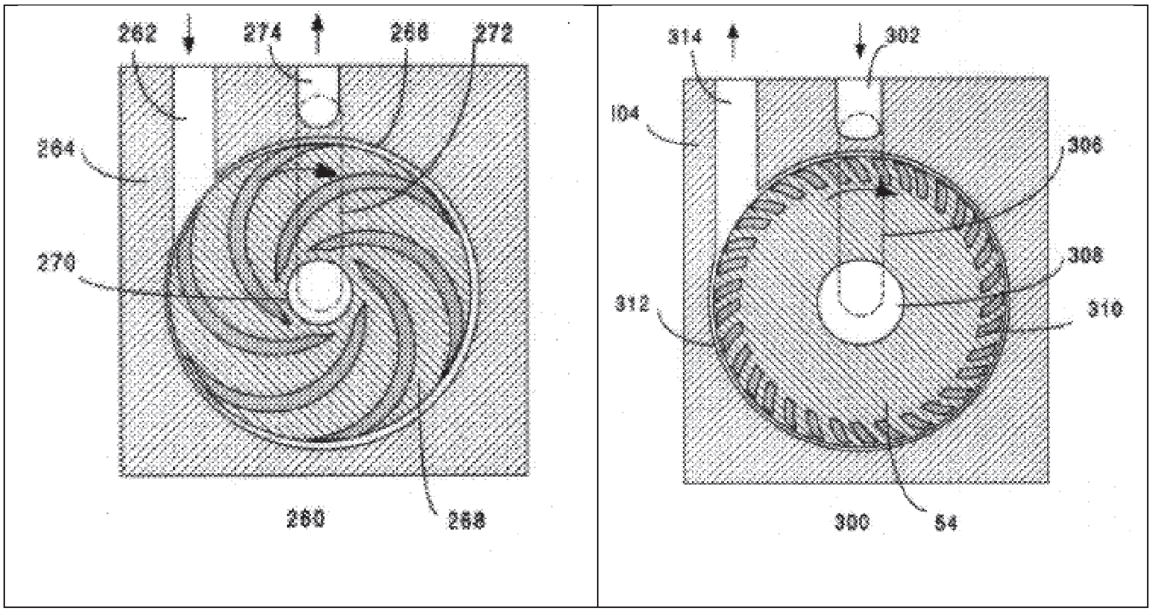


Batchelder, Figure 2



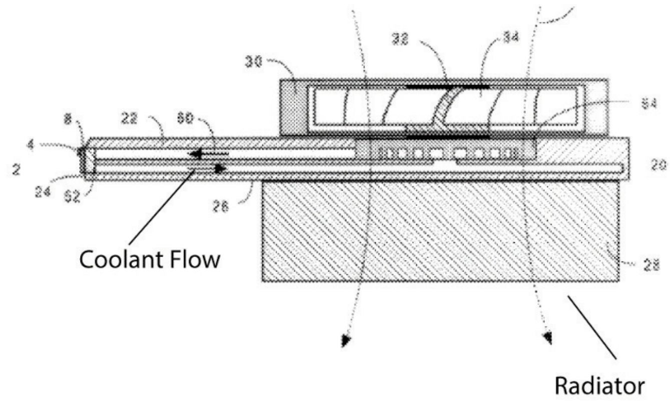
Batchelder Figure 5

120. The impeller blades of Batchelder are disclosed as having curved blades, for example, as evident in the following images:

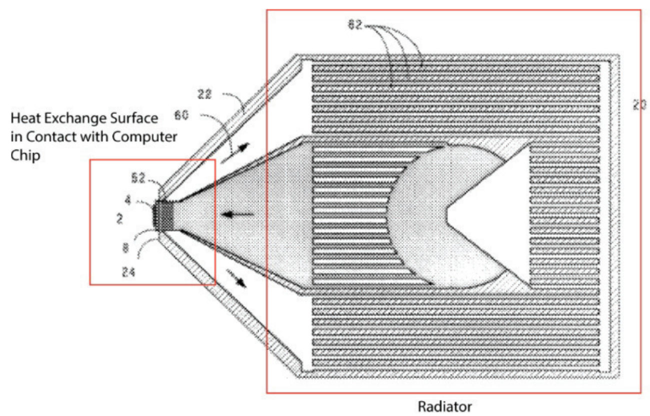


Batchelder Figure 9

121. Batchelder further teaches that the coolant is circulated through the reservoir and the heat exchanger, as shown below. A POSA would know that curved blades result in different thermal and fluid performance than straight blades and a POSA would know how to select between curved and straight blade systems.



Batchelder, Figure 4



Batchelder, Figure 4

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

122. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin; I adopt that prior analysis in Ground 1 here.

123. To the extent this was not disclosed or taught from Shin, it would have been obvious to a POSA based on her experience, education, and training. Fans are ubiquitous in their use directing air through heat radiators. Often air fans are operated with a motor separate from

the motor of the liquid pump. In fact, liquid and air blowers tend to have very different RPM and torque requirements, which would have motivated a POSA to use separate motors. A POSA would also have been motivated to use a separate motor because air fans are typically purchased with their own locomotive system. Furthermore, separate motors allow the air fan and the liquid pump to be controlled separately based on the heating requirements of the system. This allows impeller speeds to be modulated independently, reducing noise and wasted energy. Furthermore, separate motors provide a safety measure – for example, if the fan motor fails the pump motor will continue to operate and provide cooling.

124. To the extent this was not disclosed or taught based on Shin and the knowledge of a POSA, it would have been obvious in view of Batchelder. In addition, the torque requirements for an air fan and a liquid pump tend to be very different and would have preferably been driven by different motors generating different torques from a POSA's perspective. These factors would have motivated a POSA to use two different motors.

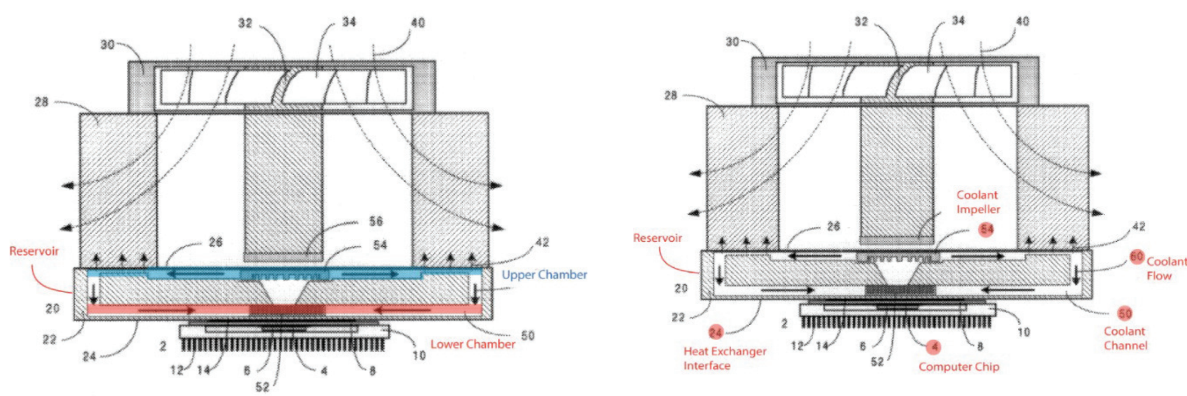
Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

125. As I have already discussed, the pump, circulating fluid, and upper and lower chambers of Claim 18 were disclosed or taught by Shin (as modified); I adopt that prior analysis in Ground 1 here.

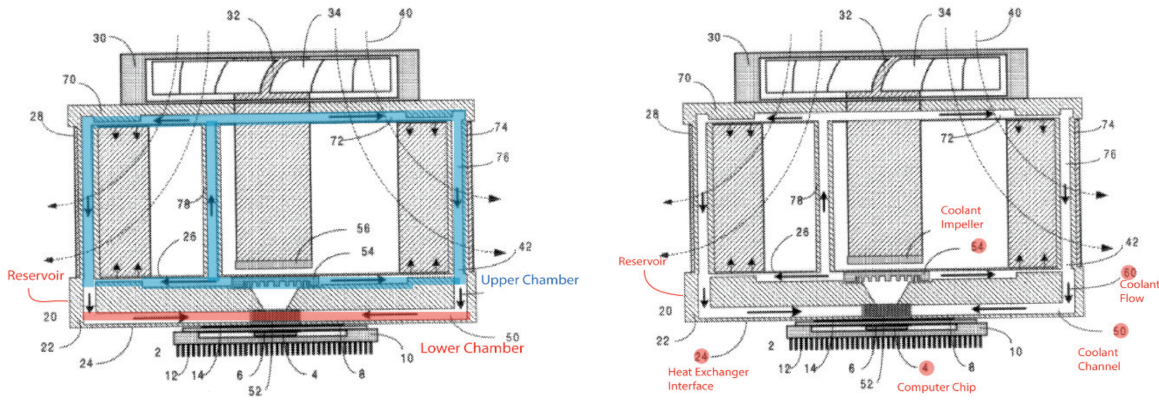
126. To the extent this claim was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. A POSA would find it

routine to use a pump to circulate cooling liquid between upper and lower chambers of a reservoir. I have used such fluid pumps multiple times myself.

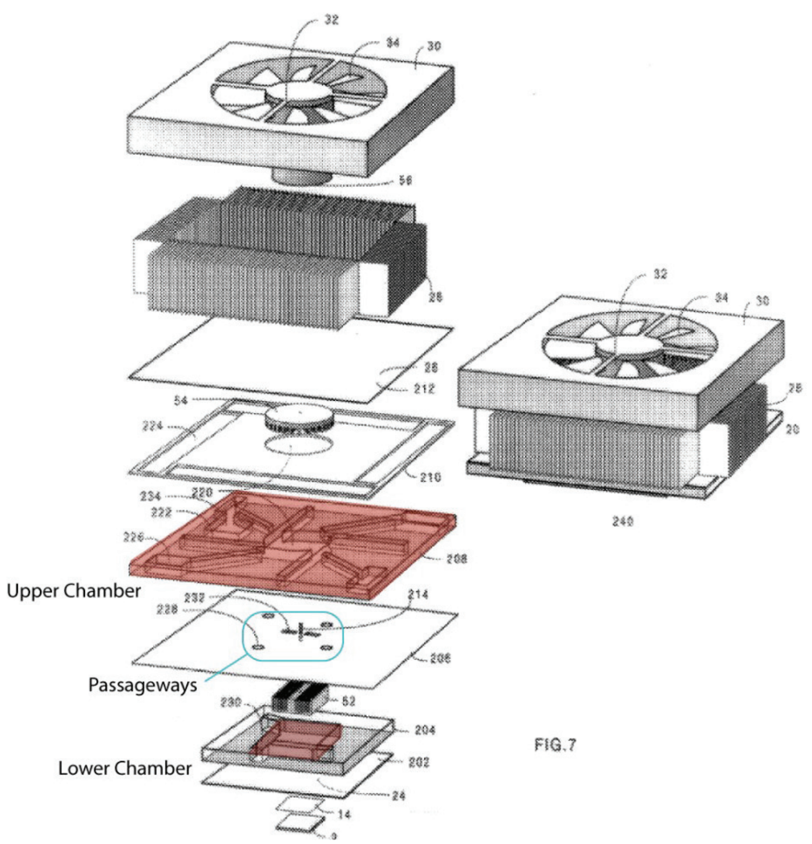
127. If this claim was not disclosed or taught with Shin in view of the experience, education, and training of a POSA, it would have been obvious in view of Batchelder. Batchelder discloses a pump that circulates cooling liquid between upper and lower chambers of a reservoir as shown in the following images. A POSA would have been motivated to use a pump that circulates cooling liquid between and upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.



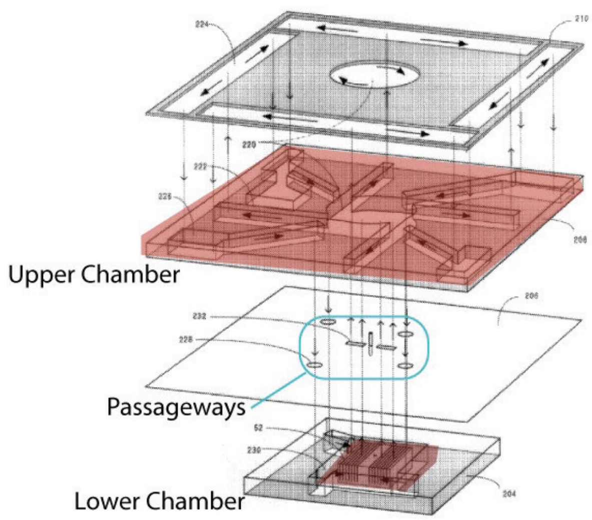
Batchelder Figure 2



Batchelder Figure 5



Batchelder, Figure 7



Batchelder, Figure 8

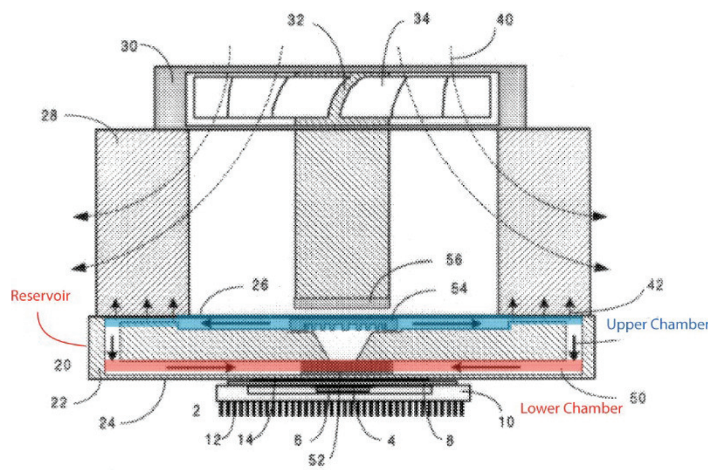
Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

128. As I have already discussed, Claim 19 was disclosed or taught by Shin (as modified); I adopt that prior analysis here. Shin teaches circulating cooling liquid between upper and lower chambers including the passing of cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

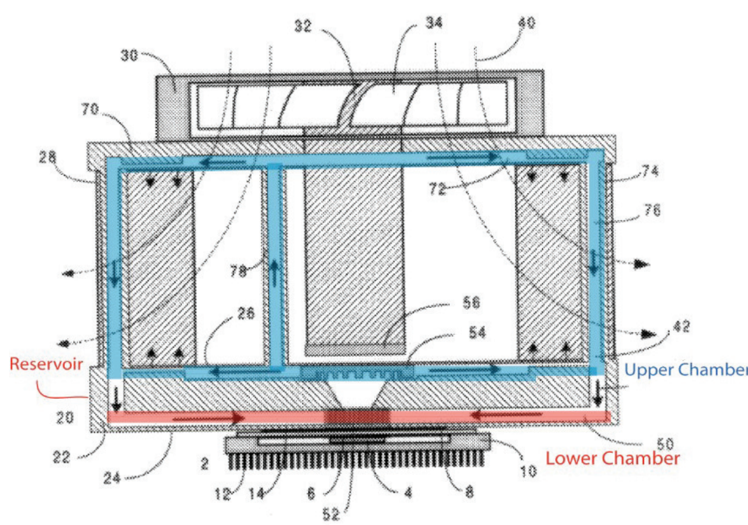
129. If it was not disclosed or taught based on Shin alone, then it would have been obvious to a POSA based on her experience, education, and training. The circulating of cooling liquid between two chambers through a single passageway is a trivial design exercise for a POSA working on the thermal management of electronics.

130. To the extent it was not disclosed or taught based on Shin and the knowledge of a POSA, it would have been obvious in view of Batchelder.

131. Batchelder discloses the circulation of a cooling liquid between upper and lower chambers through a single passageway. The circulating of liquid is shown by the following images:

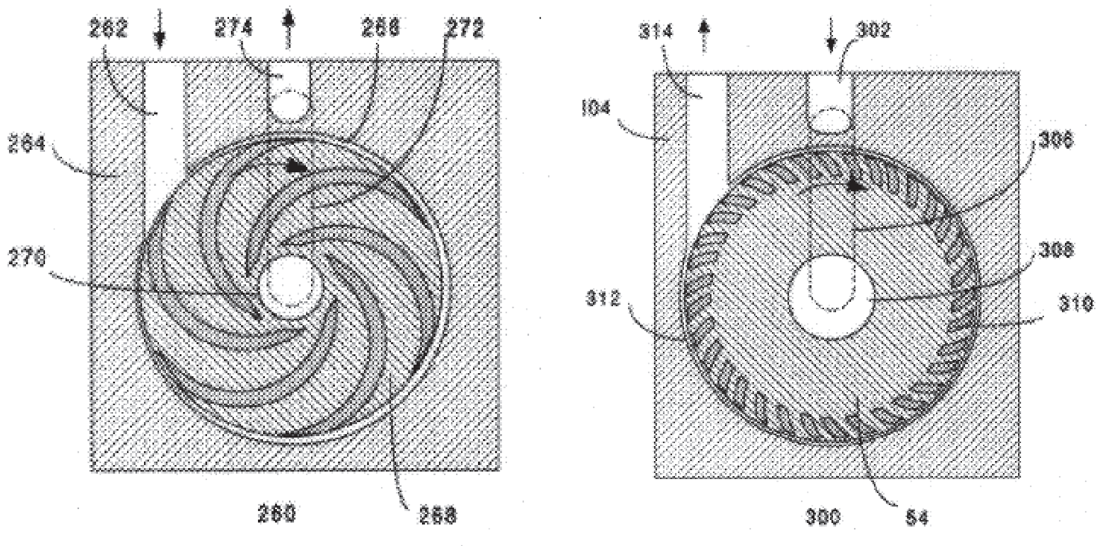


Batchelder, Figure 2



Batchelder Figure 5

132. Batchelder discloses or teaches a number of impeller designs for causing coolant flow, as indicated by comparing the flow direction arrows in the following figures. The image on the left brings fluid in at the perimeter of the impeller and pushes the fluid downwards at the center of the impeller. The design on the right is the opposite, fluid is drawn into the center of the impeller and expelled at the perimeter. When the impeller design on the right is used, the fluid travels vertically upwards, from the lower chamber to the upper chamber through the single center passageway of Figures 2 and 5. The fluid returns to the bottom chamber at the outermost channel(s). On the other hand, when the left-hand impeller is used, the fluid is drawn in at the impeller perimeter and expelled at the impeller center. With this arrangement, flow will travel from the lower to the upper reservoir at the outermost channel(s) and return to the lower chamber through the single central passageway. Both directions of flow are taught by Batcheler. A POSA would have been motivated to use a pump that circulates cooling liquid between and upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections



Batchelder Figure 9

C. **Ground 3 – Shin in View of Laing**

133. It is my opinion that Shin, in view of Laing and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid by obviousness.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

134. As I have already discussed, the preamble of Claim 17 was disclosed or taught by Shin; I adopt that prior analysis in Ground 1 here.

135. To the extent this was not disclosed or taught with Shin alone, it would have been obvious in view of the knowledge of a POSA or in view of Laing. Liquid cooling systems

for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics.

136. Such liquid cooling systems were cited, for instance, in the prior art of the ’362 patent; a testament to their common use.

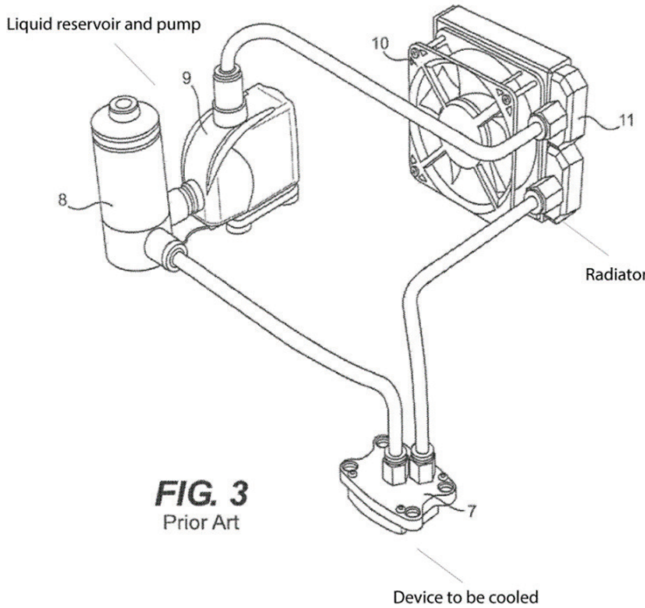


FIG. 3
Prior Art

’362 patent, Figure 3

137. Also for example, Laing discusses the use of liquid cooling systems for electronic components positioned on the motherboard of a computer system. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

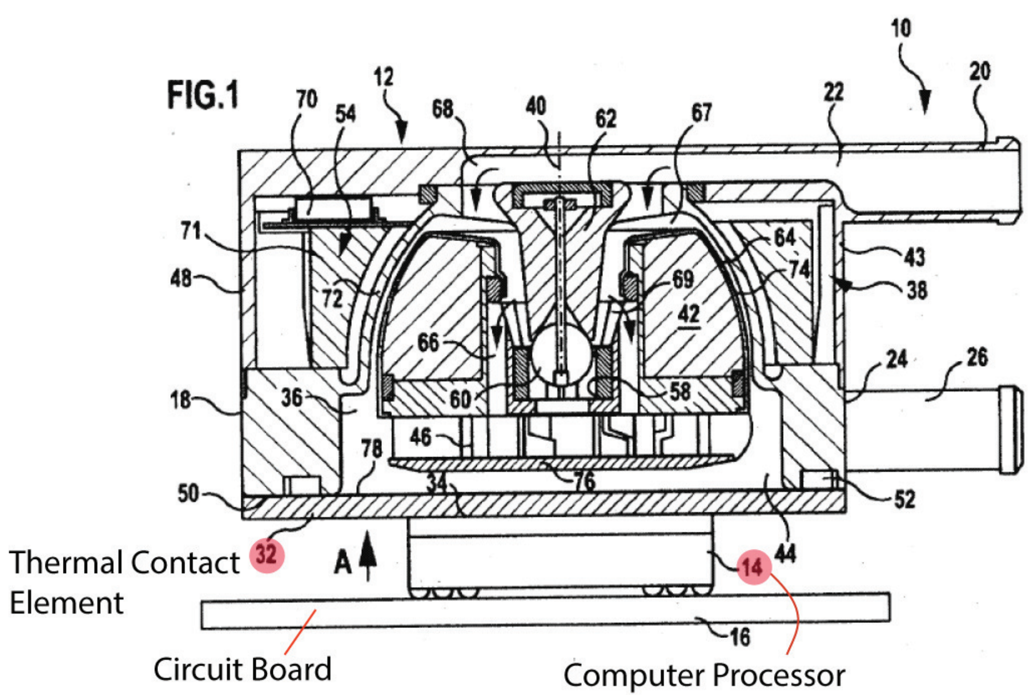
[0044] An exemplary embodiment of a device according to the invention for the local cooling or heating of an object, which is denoted overall by **10** in **FIG. 1**, comprises a circulation pump **12**, by means of which a fluid, such as water or other liquids, can be guided in a loop (**FIG. 2**) as a heat transfer medium. The heat transfer medium can be used as a cooling medium, in order to cool an object **14**, such as for example an electronic component, such as a processor, which is positioned on a circuit board **16**, for example. The heat transfer medium can also be used for heating an object.

Laing [0044]

[0072] By way of example, the object **14** is a microprocessor which is to be cooled using water.

Laing [0072]

FIG.1



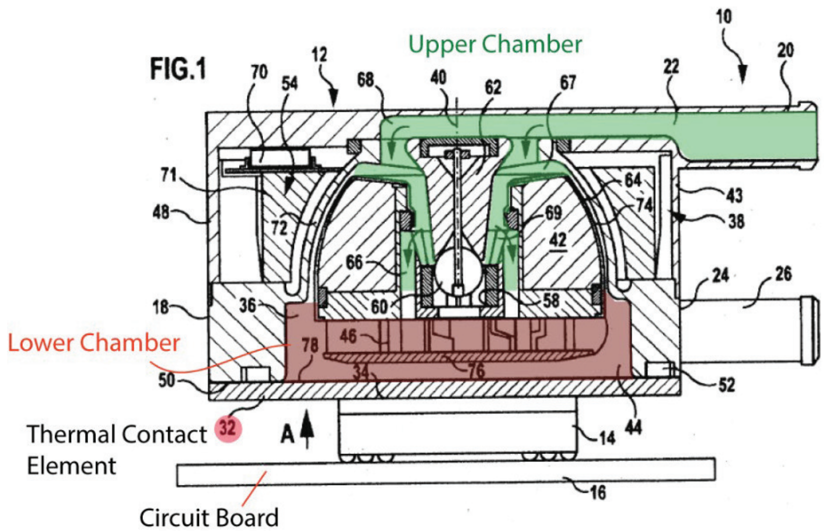
Laing Figure 1

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

138. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified); I adopt that prior analysis in Ground 1 here.

139. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. A POSA working on thermal management of computers and electronics would have routinely implemented heat exchanging interfaces that were coupled to electronic components on motherboards. I have practiced this limitation numerous times myself, and I train undergraduate and graduate students on this topic.

140. This limitation is also obvious in view of Laing, as demonstrated in the following image. There a two-chamber reservoir is shown. The bottom of the lower chamber is formed by a heat exchanging interface of the reservoir that is coupled with the electronic component positioned on the motherboard. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.



Laing, Figure 1

141. Laing also discusses the coupling between the thermal contact interface and the component to be cooled throughout the specification, with the following serving as representative examples.

> [0004] In accordance with the invention, a device for the local cooling or heating of an object is provided which is of simple design since a thermal contact element for making thermal contact with the object is integrated in the circulation pump.
>
> [0005] Therefore, according to an embodiment of the invention, a thermal contact element such as a heat sink or heater which is brought into contact with the object is part of the circulation pump. In this way, it is possible to achieve a compact design of a liquid cooling device or heating device with effective cooling or heating of the object with which contact is made.

Laing [0004-0005]

[0006] Furthermore, it is possible to achieve a high level of efficiency with regard to the cooling or heating, since a fluid is accelerated before it is brought in contact with the thermal contact element, and the flow which is generated makes it possible to achieve good thermal contact with the thermal contact element. It is then possible for heat to be optimally dissipated or optimally supplied. It is also possible to use the circulation pump to establish a flow pattern which is optimal for the removal (dissipation) of heat or supply of heat.

[0007] By suitably shaping the thermal contact element, in particular such that it is matched to a contact surface of the object, it is possible to achieve a good cooling function or heating function in combination with minimized dimensions.

Laing [0006-0007]

[0010] In particular, in this case the thermal contact element is a boundary of a swirl chamber of the circulation pump and confines the swirl chamber at least at one end thereof. In the swirl chamber, a swirl is produced in the liquid, and at an outlet this swirl is converted in a spiral pump housing into pressure for circulation of the liquid. If the thermal contact element confines the swirl chamber, it is possible to achieve optimum thermal coupling between liquid and thermal contact element and therefore in turn to achieve an optimum dissipation of heat from or supply of heat to the object.

Laing [0010]

[0024] The thermal contact element is advantageously arranged on the pressure side of the circulation pump (and not on the suction side), in order in this way to obtain optimum flow guidance and in particular to be able to apply a flow with a high degree of turbulence to the thermal contact element, in order in turn to achieve optimum thermal coupling.

Laing [0024]

[0032] The thermal contact element is then of flexible form and/or is mounted movably on a housing of the circulation pump. Then, by way of example, the thermal contact element is formed as a flexible plate which, however, still has sufficient inherent rigidity. In this way, it is possible to provide an expansion volume for the liquid after heating and also to exert a positive pressure on the system.

[0033] It is also possible for the thermal contact element to be a thin diaphragm which positions itself against the object or is surrounded by a bellows.

Laing [0032-0033]

[0050] The thermal contact between the fluid and the object **14** is provided by a thermal contact element **32** which is integrated into the circulation pump **12**. The thermal contact element **32** preferably provides and, in particular, forms a housing cover for the housing **18**. The thermal contact element **32** may be, for example, in the shape of a plate and made from a metallic material.

[0051] To form the thermal contact, the thermal contact element **32** touches the object **14** over the largest possible surface area. It is preferable for that surface of the thermal contact element **32** which faces the object **14** to be at least as large as a contact surface of the object **14**.

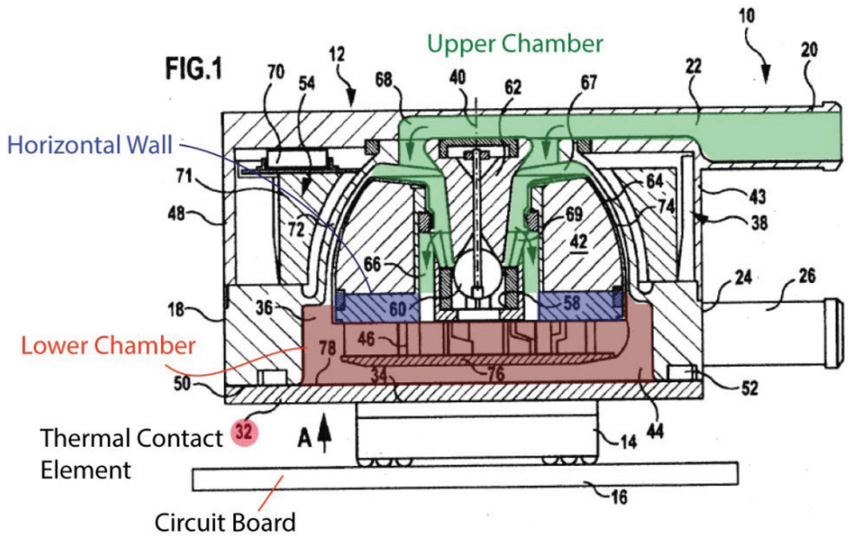
Laing [0050-0051]

… the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

142. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified); I adopt that prior analysis in Ground 1 here.

143. This limitation would also be obvious in view of Laing. For example, Laing discloses a reservoir that includes upper and lower chambers that are vertically spaced apart and

separated by at least a horizontal wall. A POSA would have been motivated to incorporate a reservoir with an upper and lower chamber vertically spaced apart and separated by a horizontal wall. The use of separated upper and lower chambers is an efficient way to route fluid from a pump to the location where heat transfer occurs.



Laing, Figure 1

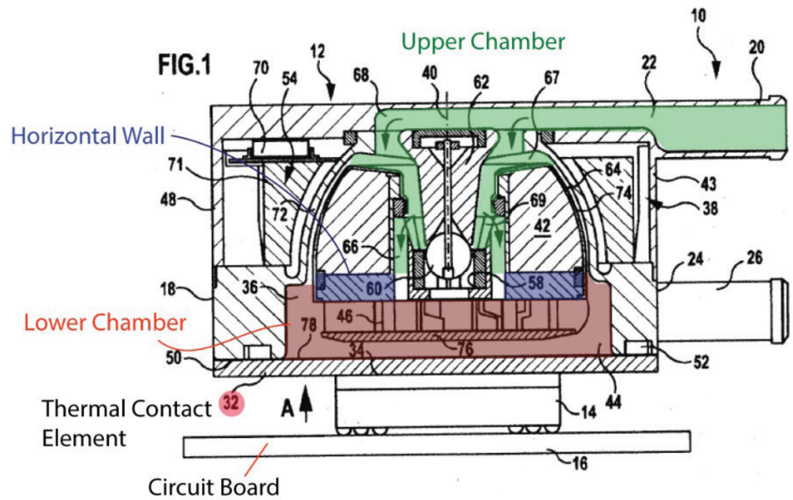
... the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

144. As I have already discussed, this portion of the first limitation of Claim 17 is disclosed or rendered obvious by Shin (as modified); I adopt that prior analysis here.

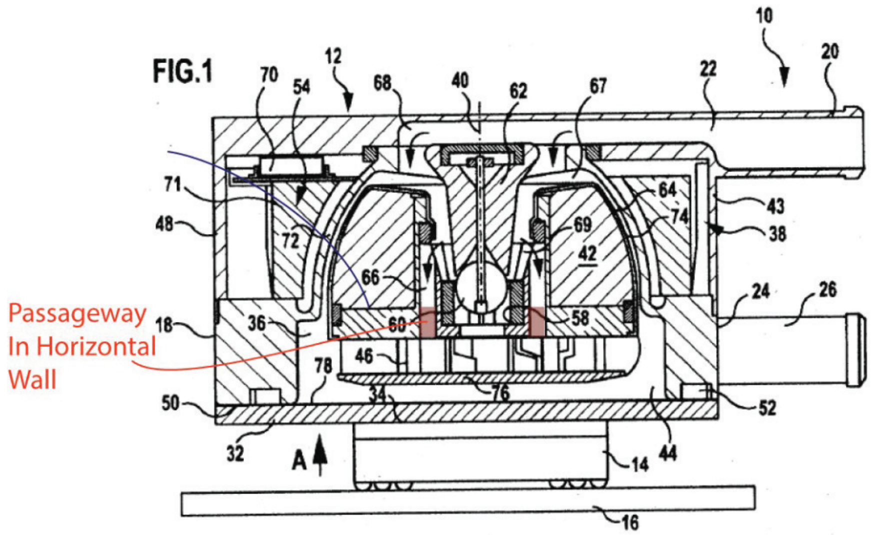
145. To the extent this was not disclosed or rendered obvious based on Shin, it would have been

obvious to a POSA in view of their experience, education, and training. To couple two fluid chambers by one or more passages would have been evident and trivial for a POSA. Furthermore, a POSA would have known that a heat exchanging interface would be removably coupled to a fluid reservoir. This coupling facilities heat transfer by reducing thermal resistance; reducing thermal resistance is obvious to a POSA and is a standard topic taught to undergraduate students in engineering. A POSA would have been motivated to use to have an upper and lower chamber coupled by one or more passages and with a heat exchanging interface removably coupled to the reservoir such that the inside surface of the heat exchanging surface is exposed to the lower chamber of the reservoir. Such a design effectively routes cooling fluid to the heated region and reduces the thermal resistance presented by the heat exchanging surface.

146. This limitation is further obvious in view of Laing. For example, in the following image from Laing, there is an upper and a lower chamber of a reservoir. The chambers are separated by a horizontal wall and there are one or more passageways positioned on the horizontal wall that fluidly couple the two chambers.

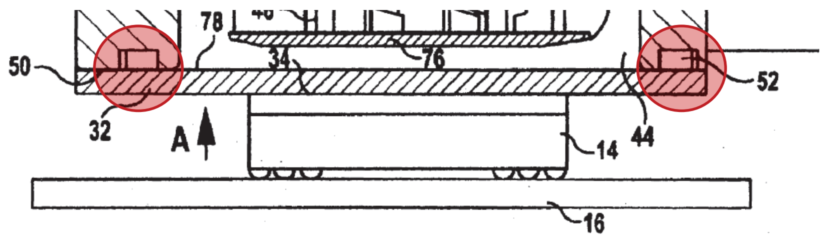


Laing Figure 1

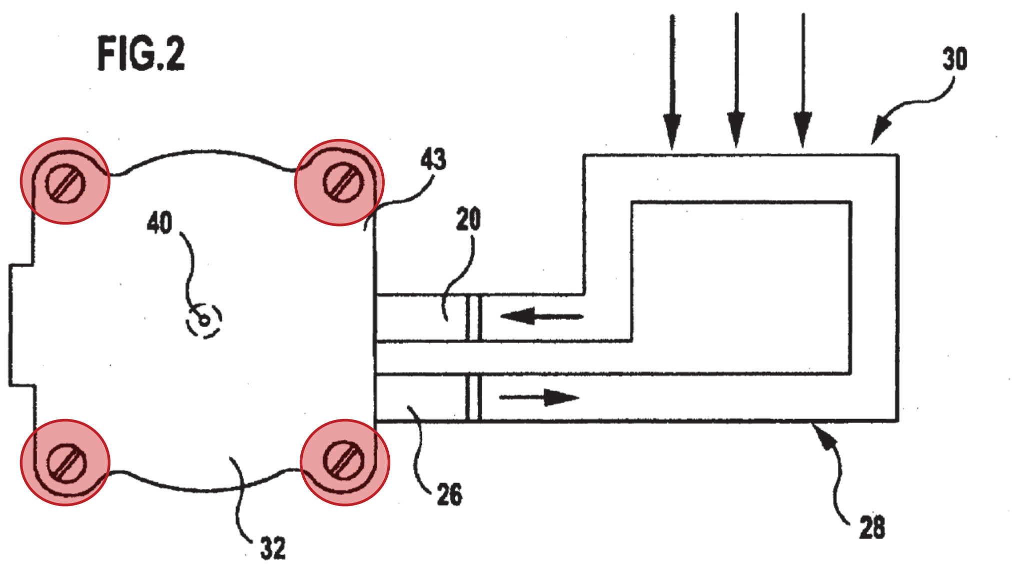


Laing Figure 1

147. Laing also discloses or teaches that its heat exchanging interface is removably coupled to the reservoir, as shown below. This is because Laing's heat exchanging interface is screwed (52) onto the reservoir.



Laing Figure 1 (excerpt)



Laing Figure 2

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

148. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin; I adopt that prior analysis here.

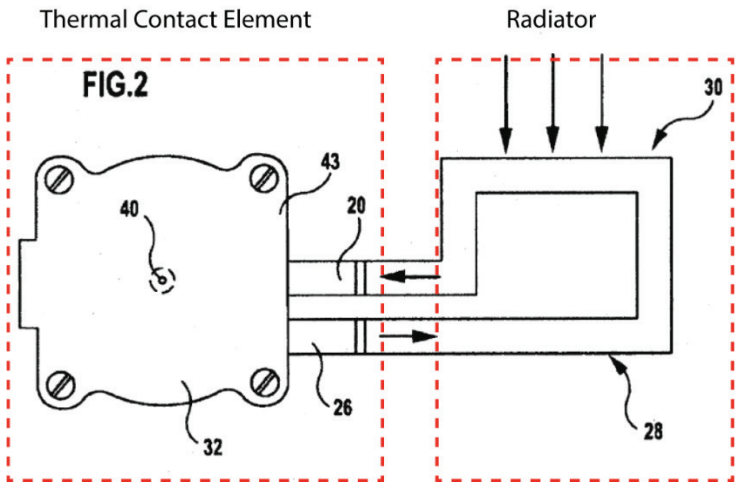
149. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious based on the experience education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by

tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems. A POSA would have been motivated to use a radiator positioned at a second location horizontally spaced apart from the first location and fluidly connected by tubing. Such an arrangement allows the heat to be transferred away from the electronic components and to the ambient environment. Horizontal tubing, when possible, is often preferred because it minimizes pressure losses within a flow.

150. To the extent this limitation was not disclosed or taught based on Shin in view of the knowledge, education, experience, and training of a POSA, it would have been obvious in view of Laing which discloses a radiator 30 that is connected to the reservoir by tubes that convey coolant.

> **[0077]** The cooling section **30** has, by way of example, a heat-transfer surface area which is three times to thirty times larger than the surface area of the inner side **78** of the thermal contact element **32** via which heat can be dissipated to the cooling water.

Laing [0077]



Laing Figure 2

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

151. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin (as modified) (except for the curved blades); I adopt that prior analysis here.

152. To the extent this limitation was not disclosed or taught in Shin, it would have been obvious to a POSA based on her experience, education, and training. Using a pump to circulate a cooling liquid through a reservoir and a heat radiator with a motor and a curved-blade impeller that is positioned in the reservoir is routinely encountered by a POSA who works on thermal management of electronics. In fact, I have worked with such systems many times in my research and teaching activities. A POSA would have known that curved blades result in different thermal and fluid performance than straight blades as well as how to select between curved and straight blade systems.

153. To the extent this was not disclosed or taught based on a POSA's experience, education, and training, it would have been obvious in view of Laing, which shows a pump that has an impeller that is positioned in the reservoir. The impeller of Laing propels fluid through the reservoir and the heat radiator as already discussed.

[0055] A swirl chamber **44**, in which a swirl is imparted to liquid which has been supplied via the feed line **20**, using an impeller **46** (paddle wheel) which is connected in a rotationally fixed manner to the rotor **42**, and in which swirling liquid flows, is formed in the interior space **36** of the housing **18**. Pressure conversion takes place in a spiral housing of the circulation pump **12**, in order for the liquid to be pumped through the circuit **28**. The liquid is also guided past the thermal contact element **32** in order to transfer heat.

Laing [0055]

[0061] The bearing cap **58** is connected in a rotationally fixed manner to the paddle wheel **46**.

Laing [0061]

[0064] A through-flow region **66**, which in particular is arranged concentrically with respect to the axis of rotation **40** and is, for example, approximately annular in cross section (with ribs disposed in the annular space), is formed around the bearing support **62** at the rotor **42**. This through-flow region **66** connects an inflow region **68** of the circulation pump **12**, which in turn is connected to the feed line **20**, to the swirl chamber **44**. The paddle wheel **46** is disposed in the swirl chamber **44**, so that the pressure side of the circulation pump **12** is formed here, while the inflow region **68** represents the suction side. Then, liquid is guided through the circulation pump **12** via the through-flow space **66**, and a swirl is imparted to the liquid which is conducted through by the paddle wheel **46**; the pressure required to pump the liquid through the loop **28** is then produced.

Laing [0064]

[0074] In this arrangement, it is possible for this inner side to have fins in order to increase the surface area, these fins being provided in particular with a structure which increases the turbulence. By way of example, circular or spiral walls project toward the paddle wheel **46**. In this way, the flow and in particular the flow of the cooling water past the thermal contact element **32** can be improved and the thermal contact can be improved, so that heat can be optimally dissipated and as a result the object **14** can be optimally cooled.

[0075] Cool cooling water is guided into the inflow region **68** via the feed line **20**. It then flows through the through-flow region **66** coaxially with respect to the axis of rotation **40**. A swirl is imparted to this cooling water by the paddle wheel **46**; this is then followed by pressure conversion in the spiral housing, in order to pump the cooling water through the loop **28**.

Laing [0074-0075]

[0076] At the paddle wheel **46**, the cooling water flows spirally outward with respect to the axis of rotation **40** and past the inner side **78** of the thermal contact element **32**. As a result, heat can be dissipated from the thermal contact element **32** and therefore in turn from the object **14** through the cooling water, which correspondingly has taken up this heat.

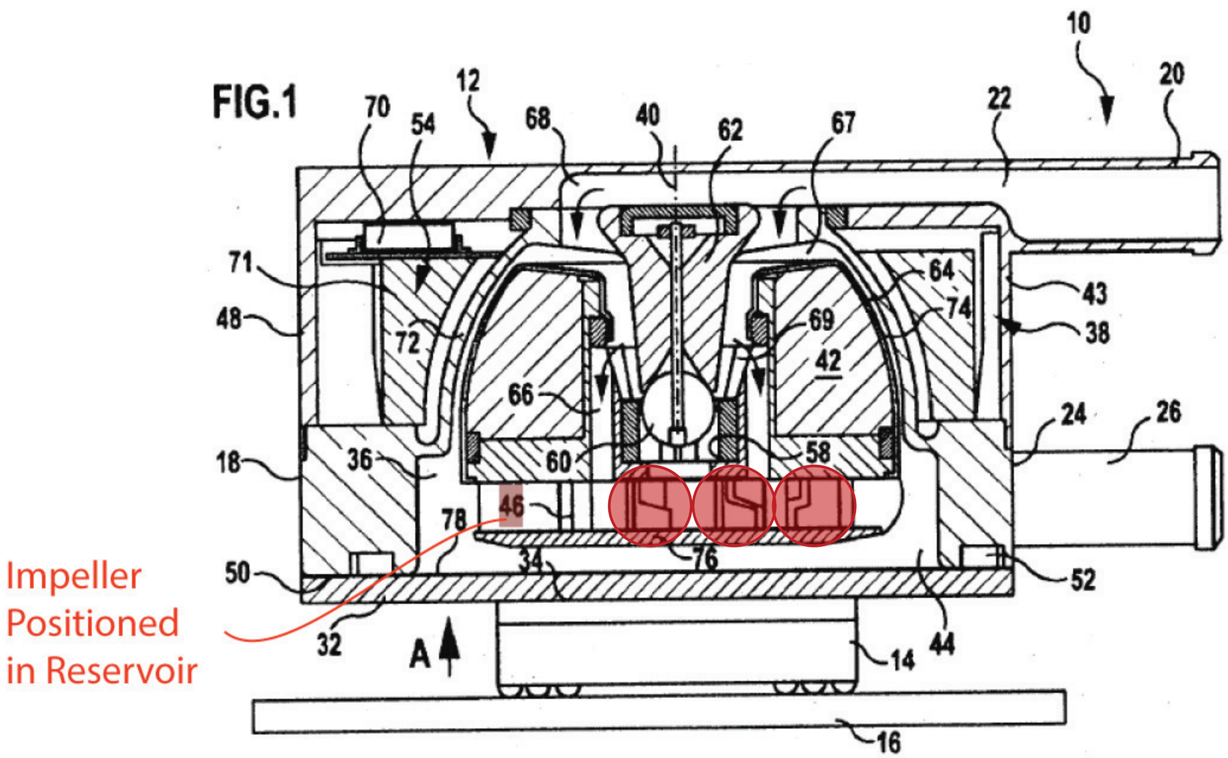
Laing [0076]

[0078] As an alternative or in addition to the paddle wheel **46**, it is possible for blades to be disposed on the rotor **42** in the air gap **74**, with the spherical symmetry of the arrangement being substantially retained.

Laing [0078]

[0080] Furthermore, it is possible to produce low overall heights in the direction of the axis of rotation **40**, so that it is possible to produce a compact device for example for cooling a microprocessor **14**. The fact that the thermal contact element **32** is integrated in the circulation pump **12**, and in particular the fact that it is designed as a housing cover, means that it is possible to achieve a simple and space-saving structure of the device **10**. In particular, there is no need for an external thermal contact element. The high flow velocities within the housing **18** of the circulation pump **12** can be utilized directly to dissipate heat from the object **14**. The paddle wheel **46** directly faces the thermal contact element **32** and therefore the object **14**.

Laing [0080]



Laing, Figure 1

154. Laing discloses or teaches a rotor (42) and stator (54) of the motor that propels the impeller of the fluid pump that is positioned in the reservoir. A POSA would have known

that the impeller blades of Laing could be straight or curved – as circled above in red, Laing's Figure 1 suggests that the blades may have curvatures; selecting or designing appropriate impeller blades is a routine and trivial exercise for a POSA working in thermal management of electronics. A POSA would have been motivated to use curved impeller blades because curving of blades allows a designer to tailor the flow and pressure through a pump. Impeller blade design and selection is taught to undergraduate students and it is a routine design choice.

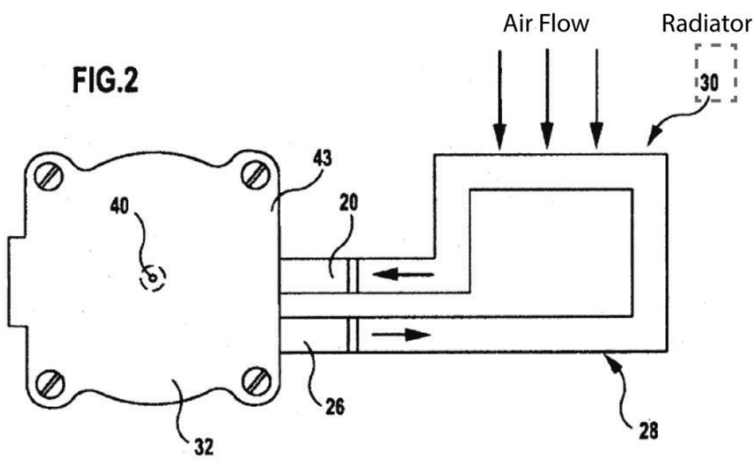
17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

155. As I have already discussed, this portion of the first limitation of Claim 17 was disclosed or taught by Shin; I adopt that prior analysis here.

156. To the extent this was not disclosed or taught from Shin, it would have been obvious to a POSA based on her experience, education, and training. Fans are ubiquitous in their use directing air through heat radiators. Often air fans are operated with a motor separate from the motor of the liquid pump. A POSA would have been motivated to use a separate motor because air fans are typically purchased with their own locomotive system. Furthermore, separate motors allow the air fan and the liquid pump to be controlled separately based on the heating requirements of the system. This allows impeller speeds to be modulated independently, reducing noise and wasted energy. Furthermore, separate motors provide a safety measure – if one motor fails the other motor will continue to operate and provide cooling. In addition, the torque requirements for an air fan and a liquid pump tend to be very different and would have preferably been driven by different motors generating

different torques from a POSA's perspective. These factors would have motivated a POSA to use two different motors.

157. To the extent this was not disclosed or taught based on Shin and the knowledge of a POSA, it would have been obvious in view of Laing. Laing teaches a separate cooling region (radiator) where heat is extracted from the coolant before the coolant is reintroduced to cool the electronic component(s). Figure 2 from Laing shows air flow across the radiator (item 30). A POSA would have known that the airflow would be caused by a fan and that the fan would operate separately from the motor of the pump.



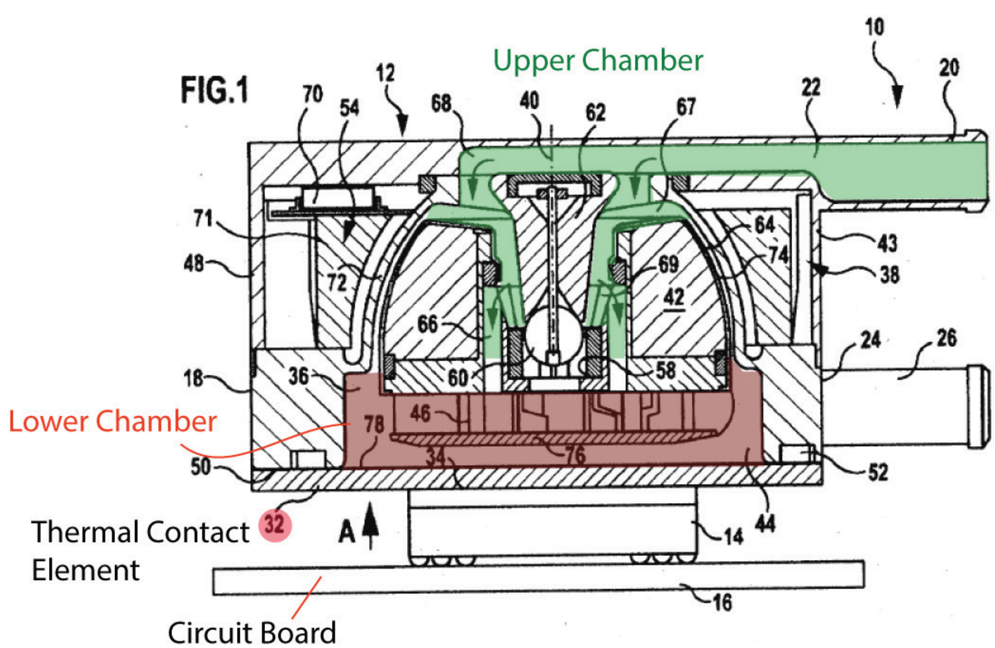
Laing Figure 2

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

158. As I have already discussed, claim 18 was disclosed or taught by Shin (as modified); I adopt that prior analysis here.

159. To the extent this claim was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. A POSA would have found it routine to use a pump to circulate cooling liquid between upper and lower chambers of a reservoir. I have used such fluid pumps multiple times myself. A POSA would have been motivated to use a pump that circulates cooling liquid between and upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.

160. To the extent this claim was not disclosed or taught with Shin in view of the experience, education, and training of a POSA, it would have been obvious in view of Laing. Laing discloses a pump that circulates cooling liquid between upper and lower chambers of a reservoir as shown in the following images.



Laing Figure 1

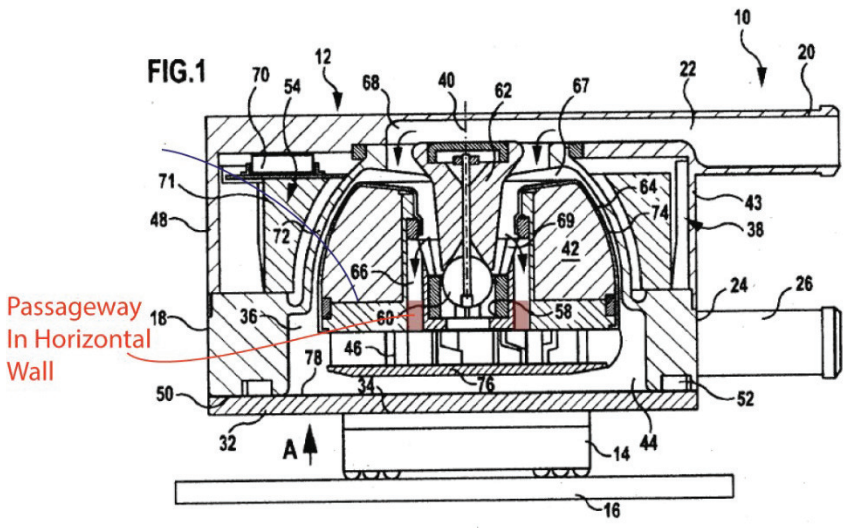
Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

161. As I have already discussed, claim 19 was disclosed or taught by Shin (as modified); I adopt that prior analysis here. Shin teaches circulating cooling liquid between upper and lower chambers including the passing of cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

162. If it was not disclosed or taught based on Shin alone, then it would have been obvious to a POSA based on her experience, education, and training. The circulating of cooling liquid between two chambers through a single passageway is a trivial design exercise for a POSA working on the thermal management of electronics. A POSA would have been motivated to use a pump that circulates cooling liquid between and upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.

163. To the extent it was not disclosed or taught based on Shin and the knowledge of a POSA, it would have been obvious in view of Laing.

164. Laing discloses the circulation of a cooling liquid between upper and lower chambers through a single passageway (annular passageway). The circulating of liquid is shown by the following images:



Laing, Figure 1

D. Ground 4 – Ryu in View of Wu

165. It is my opinion that Ryu, in view of Wu and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid by obviousness.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

166. While I do not understand that the preamble to this claim is limiting, if it is limiting then Ryu discloses this preamble. First, Ryu is entitled “WATER COOLED COOLING DEVICE FOR THE CENTRAL PROCESSING UNIT OF A COMPUTER WITH AN IMPELLER”

167. Ryu further discloses or teaches the following:

Abstract

The present invention relates to a water-cooled cooling device for a computer's central processing unit having an impeller for circulating the water-cooled by a radiator inside a water jacket provided on the upper surface of the central processing unit of the computer to cool the heat generated from the central processing unit, and

Comprises a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit;

An impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and

A drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

Ryu, Abstract

Technical problems to be solved by the invention

The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for cooling the heat generated from the central processing unit using the circulating cooling water.

Ryu, Page 3

Comprises a pump driving unit having a first inlet, discharging unit, and a first outlet; and a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water, or

A pump driving unit having a first inlet, discharging unit, and a first outlet; a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water; an inlet pipe exposed and formed between the water jacket and the pump driving unit to connect the first inlet and the second inlet; and a discharge pipe exposed and formed between the water jacket and the pump driving unit to connect the discharging unit and the second outlet, and in this case, it is preferable that the coupling clip mounts the water jacket to the central processing unit.

The water jacket is made of aluminum material, and specifically, a plurality of porous aluminum plates having a plurality of holes formed in a shape of a honeycomb is stacked and then joined by a brazing technique to form multiple water passages on the inside of the water jacket.

Ryu, Page 4

In order to achieve the said object, a water-cooled cooling device for computer central processing units having an impeller according to the present invention is a water-cooled cooling device for computer central processing units capable of cooling the central processing unit of a computer by receiving the cooled water and circulating therein, and is characterized by comprising a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit; an impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and a drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

In addition, it further comprises a coupling clip for mounting the combination of the circulation unit, impeller, and drive motor to the central processing unit,

Ryu, Page 4

In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit.

Ryu, Page 4

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, Page 5

As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

Ryu, Page 6

In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.[1]

Ryu, Page 7

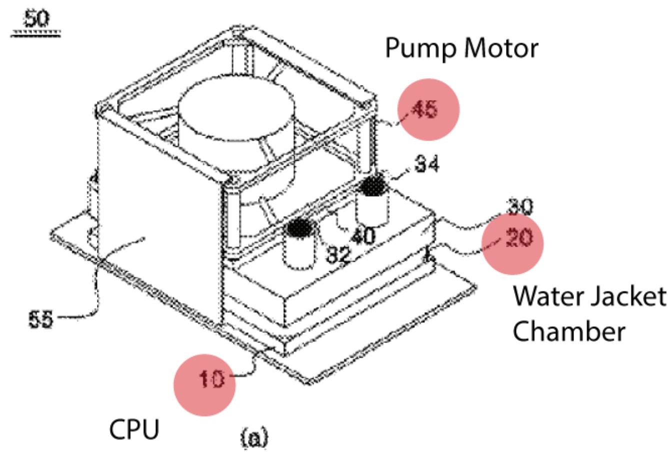
168. The preamble is also obvious in view of the knowledge of a POSA or in view of Wu, as I have already discussed. I adopt that prior analysis here. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

17(a) … a reservoir … the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

169. This limitation is obvious over Ryu in view of Wu. Ryu does not disclose or teach a single-receptacle "reservoir" having two chambers, but Wu discloses or teaches such a "reservoir," as I have already discussed. I adopt that prior analysis here. A POSA would have been motivated to modify Ryu in view of Wu to combine Ryu's pump driving unit and water jacket into a "single receptacle defining a fluid flow path." A POSA would

have been motivated to incorporate a separably heat exchange surface with an electronic component because this promotes excellent heat transfer from the heat generating device.

Figure 2



Ryu, Figure 2

separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard ….

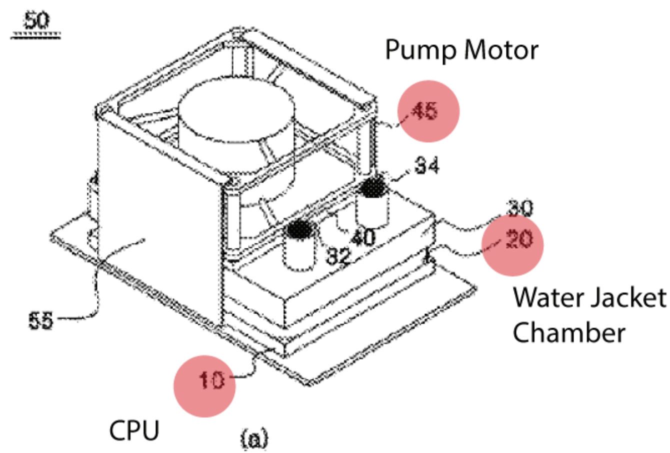
170. Ryu discloses or teaches the claimed separably thermally coupling of a heat exchanging interface of a reservoir (in the Ryu device as modified in view of Wu with a single-receptacle structure having a pump drive integrated with the water jacket as discussed above) with the electronic component positioned at a first location on a motherboard, as shown here:

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

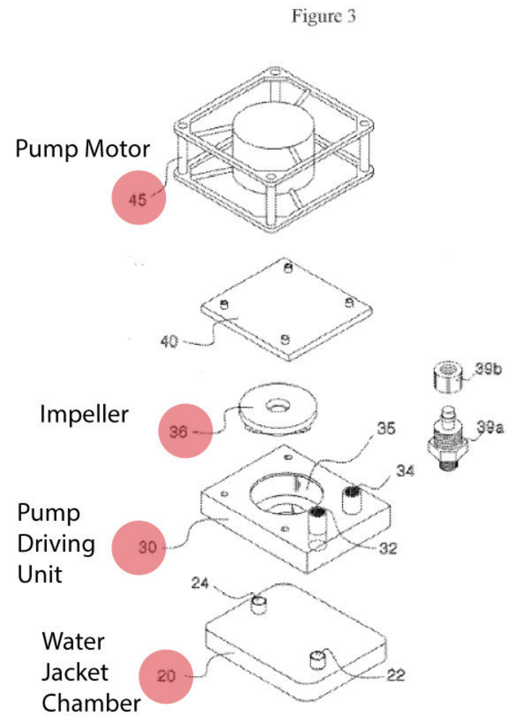
The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, page 5

Figure 2



Ryu, Figure 2



Ryu, Figure 3

171. As seen above, Ryu includes a heat exchanging interface of a reservoir (lower surface of the water jacket 20), that is coupled with the electronic component positioned on a motherboard.

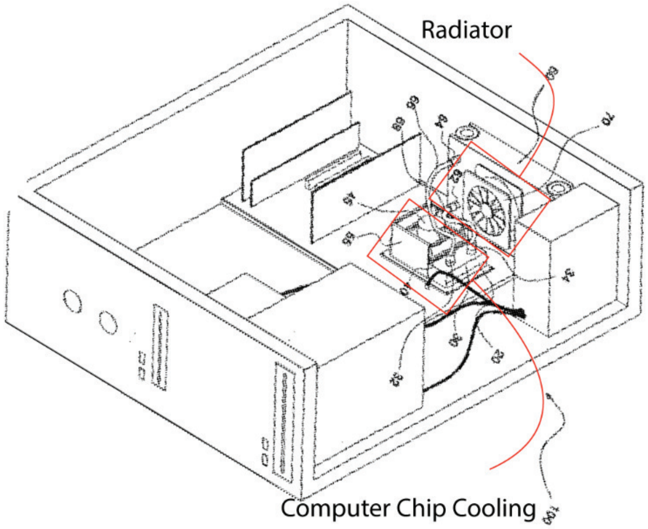
172. This limitation is also obvious in view of the knowledge of a POSA or in view of Wu, as I have already discussed. I adopt that prior analysis here.

… the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir;

173. This limitation is obvious over Ryu in view of Wu. This is because Wu discloses or teaches this limitation, as I have already discussed. I adopt that prior analysis here. A POSA would have been motivated to use an upper and lower chamber coupled by one or more passages and with a heat exchanging interface removably coupled to the reservoir such that the inside surface of the heat exchanging surface is exposed to the lower chamber of the reservoir. Such a design effectively routes cooling fluid to the heated region and reduces the thermal resistance presented by the heat exchanging surface.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

174. This limitation is obvious over Ryu, which includes a radiator at a second location horizontally spaced apart from the first location. The radiator and the reservoir are fluidly coupled by tubing as claimed.



Ryu, Figure 1

Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

Ryu, Page 5

The radiator (60) performs cooling by the operation of the cooling fan (70) while circulating the water for which the temperature has risen while passing through the water jacket (20). In this case, the cooling fan (70) may be provided at the front side of the radiator to circulate the internal air of the computer desktop (100), or it may be provided at the rear side of the radiator and a plurality of holes may be formed on the back surface of the computer desktop to have the cooling fan circulate the air from the outside, thereby enhancing the cooling efficiency of the radiator. The location of the cooling fan (70) may be freely changed according to the situation of the system.

Ryu, Page 6

175. To the extent this limitation was not disclosed or taught by Ryu, it would have been obvious to a POSA based on her education, experience, and training, as I have already discussed. I adopt that earlier discussion here.

176. To the extent this limitation was not disclosed or taught with Ryu in light of the knowledge of a POSA, it would have been obvious in view of Wu, as I have already discussed. I adopt that earlier analysis here. A POSA would have been motivated to use a radiator positioned at a second location horizontally spaced apart from the first location and fluidly connected by tubing. Such an arrangement allows the heat to be transferred away from the electronic components and to the ambient environment. Horizontal tubing, when possible, is often preferred because it minimizes pressure losses within a flow.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

177. Ryu discloses or teaches this claim limitation (except the single-receptacle aspect of the "reservoir" or the "curved blades"). Ryu includes a pump that circulates cooling liquid through the receptacles and the heat radiator. The pump includes a motor and an impeller having blades with the impeller positioned in the pump driving unit.

Abstract

The present invention relates to a water-cooled cooling device for a computer's central processing unit having an impeller for circulating the water-cooled by a radiator inside a water jacket provided on the upper surface of the central processing unit of the computer to cool the heat generated from the central processing unit, and

Comprises a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit;

An impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and

A drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

Ryu, Abstract

Technical problems to be solved by the invention

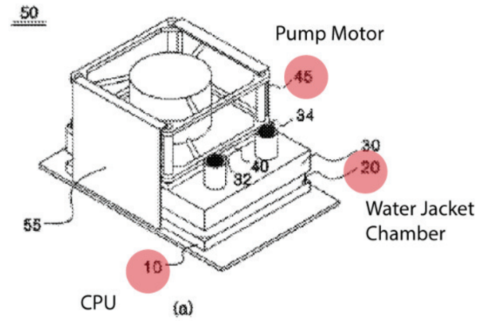
The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for cooling the heat generated from the central processing unit using the circulating cooling water.

Ryu, Page 3

In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit.

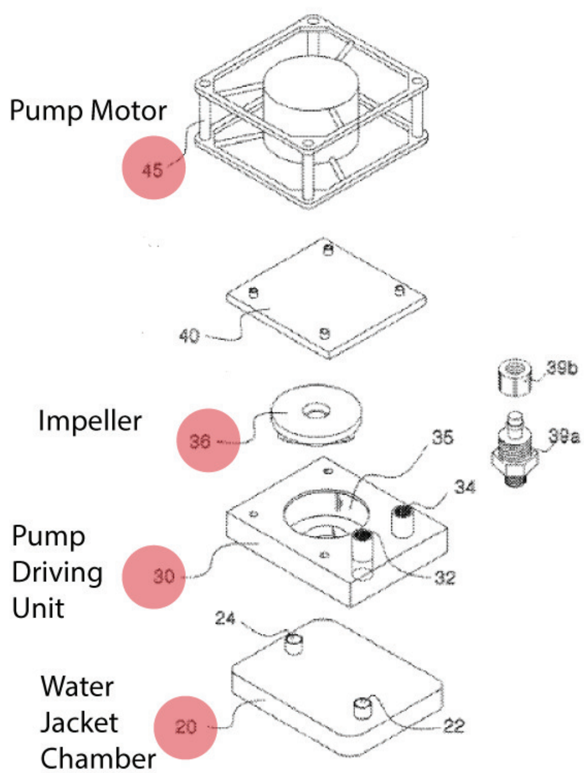
Ryu, Page 4

Figure 2



Ryu, Figure 2

Figure 3



Ryu, Figure 3

178. To the extent this limitation was not disclosed or taught in Ryu, it would have been obvious to a POSA based on her experience, education, and training. Using a pump to circulate a cooling liquid through a reservoir and a heat radiator with a motor and a curved-blade impeller that is positioned in the pump driving unit is routinely encountered by a POSA who works on thermal management of electronics. In fact, I have worked with such systems many times in my research and teaching activities as I have already discussed. I adopt that prior discussion here. A POSA would have known that curved blades result in different thermal and fluid performance than straight blades as well as how to select between curved and straight blade systems.

179. To the extent that any portion of this limitation was not disclosed or rendered obvious by Ryu alone or in view of a POSA, it was disclosed or taught by Wu. I have already analyzed this limitation using Wu, and I adopt that earlier analysis here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

180. Ryu discloses a fan activated to direct air through the heat radiator, with the fan being operated by a motor different from the motor of the pump. The following text supports my opinion.

> Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

Ryu, page 5

The radiator (60) performs cooling by the operation of the cooling fan (70) while circulating the water for which the temperature has risen while passing through the water jacket (20). In this case, the cooling fan (70) may be provided at the front side of the radiator to circulate the internal air of the computer desktop (100), or it may be provided at the rear side of the radiator and a plurality of holes may be formed on the back surface of the computer desktop to have the cooling fan circulate the air from the outside, thereby enhancing the cooling efficiency of the radiator. The location of the cooling fan (70) may be freely changed according to the situation of the system.

Ryu, Page 6

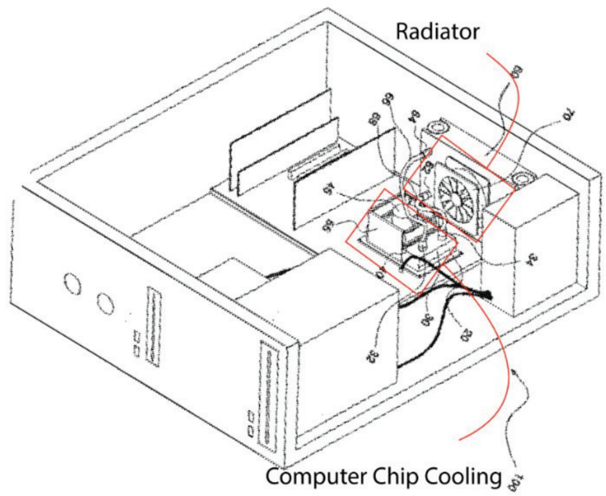
As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

Ryu, page 6

In addition, a cooling fan (70) for cooling the water passing through each water passage (65a) inside the radiator is mounted on the front or back surface of the radiator (60). When the cooling fan (70) is mounted to the front surface of the radiator, the components mounted on the inside can be cooled by circulating the air inside the computer desktop.

Ryu, page 10



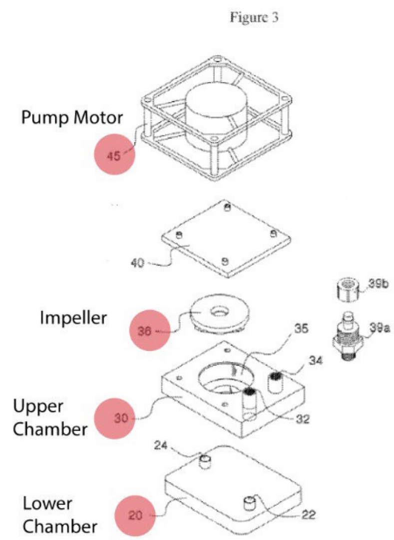
Ryu, Figure 1

195. To the extent this limitation is not made obvious by Ryu, it would have been obvious to a POSA based on her experience, education, and training, as I have already discussed. In addition, the torque requirements for an air fan and a liquid pump tend to be very different and would preferably be driven by different motors generating different torques from a POSA's perspective. These factors would have motivated a POSA to use two different motors.

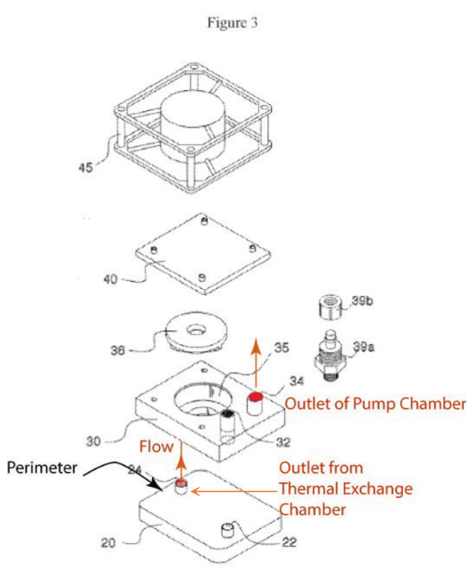
196. Furthermore, to the extent this limitation is not rendered obvious by Ryu in view of a POSA's knowledge, it would have been obvious in view of Wu, as I have already discussed. I adopt my earlier discussion of Wu here.

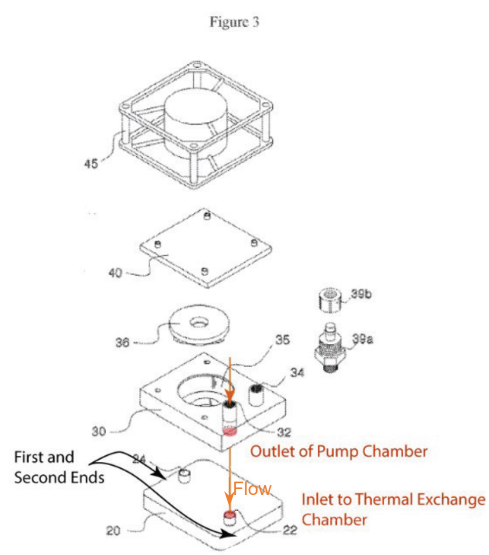
Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

197. Ryu discloses a pump activated to circulate cooling liquid between the upper and lower chambers of the reservoir, as shown below.



Ryu, Figure 3





Ryu, Figure 3

198. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA, based on her experience, education, and training to activate a pump for circulating cooling liquid between the upper and lower chambers of the reservoir. A POSA who works using liquid pumps or on thermal management of electronics would have been familiar with pumps that circulate liquid between upper and lower chambers of a reservoir. Furthermore, it is a simple way to direct liquid from the impeller to the surface to be cooled, in a hydrodynamically efficient way. In fact, I have instructed students for years on designing and evaluating such pumps. A POSA would have been motivated to use a pump that circulates cooling liquid between an upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

181. For reasons similar to those articulated with claim 18, Ryu discloses or teaches this limitation, either alone or in combination with the knowledge of a POSA. I adopt that analysis here. A POSA would have been motivated to use a pump that circulates cooling liquid between an upper and a lower chamber of the reservoir because this is an efficient way to route liquid to close proximity with the heat-generating components, to ensure intimate thermal connection, and to minimize piping and tubing and their connections.

E. Ground 5 – Ryu in View of Batchelder

182. It is my opinion that Ryu, in view of Batchelder and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

183. As I have already discussed, the preamble of Claim 17 was disclosed or taught by Ryu; I adopt that prior analysis in Ground 4 here.

184. To the extent this was not disclosed or taught with Ryu alone, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics, as I have already discussed. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

185. To the extent this preamble was not disclosed or taught by Ryu in view of the experience, education, and training of a POSA, it would have been obvious in view of Batchelder, as I have already explained. I adopt that prior analysis here.

17(a) … a reservoir … the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

186. This limitation is obvious over Ryu in view of Batchelder. This is because, as an initial matter, Batchelder discloses or teaches a "reservoir," as I have already discussed. I adopt that prior analysis here. A POSA would have been motivated to modify Ryu in view of Batchelder to integrate Ryu's pump driving unit and water jacket into a "single receptacle defining a fluid flow path."

187. This limitation would have been obvious over Ryu in view of Batchelder. For example, Batchelder discloses a reservoir that includes upper and lower chambers that are vertically spaced apart and separated by at least a horizontal wall. I adopt my earlier discussion of Batchelder related to this portion of the claim limitation here. A POSA would have been motivated to incorporate into Ryu a reservoir with an upper and lower chamber vertically spaced apart and separated by a horizontal wall like that in Batchelder. The use of separated upper and lower chambers is an efficient way to route fluid from a pump to the location where heat transfer occurs.

separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

188. As I have already discussed, this portion of the first limitation of Claim 17 is disclosed or rendered obvious by Ryu; I adopt that prior analysis here.

189. To the extent this limitation was not disclosed or rendered obvious by Ryu, it would have been obvious to a POSA based on her experience, education, and training. A POSA working on thermal management of computers and electronics would have routinely implemented heat exchanging interfaces that are coupled to electronic components on motherboards, as I have already discussed. A POSA would have been motivated to

incorporate a separable heat exchange surface with an electronic component because this promotes excellent heat transfer from the heat generating device.

190. This limitation is further obvious in view of Batchelder, as I have explained. I adopt that earlier discussion here.

… the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

191. As I have already discussed, this portion of the first limitation of Claim 17 is disclosed or rendered obvious by Ryu; I adopt that prior analysis here.

192. To the extent this was not disclosed or taught based on Ryu, it would have been obvious to a POSA in view of their experience, education, and training. To couple two fluid chambers by one or more passages would have been evident and trivial for a POSA. Furthermore, a POSA would have known that a heat exchanging interface would be removably coupled to a fluid reservoir. This coupling facilities heat transfer by reducing thermal resistance; reducing thermal resistance is obvious to a POSA and is a standard topic taught to undergraduate students in engineering, as I have already discussed.

193. This limitation is further obvious in view of Batchelder. For example, in Batchelder, there is an upper and a lower chamber of a reservoir. The chambers are separated by a horizontal wall and there are one or more passageways positioned on the horizontal wall that fluidly couple the two chambers. I have already discussed Batchelder in relation to this portion of the claim limitation and I adopt that earlier analysis here. A POSA would have been

motivated to use an upper and lower chamber coupled by one or more passages and with a heat exchanging interface removably coupled to the reservoir such that the inside surface of the heat exchanging surface is exposed to the lower chamber of the reservoir. Such a design effectively routes cooling fluid to the heated region and reduces the thermal resistance presented by the heat exchanging surface.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

194. As I have already discussed, this portion of Claim 17 was disclosed or taught by Ryu; I adopt that prior analysis here.

195. To the extent this was not disclosed or taught based on Ryu alone, it would have been obvious based on the experience, education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems, as I have already discussed. A POSA would have been motivated to use a radiator positioned at a second location horizontally spaced apart from the first location and fluidly connected by tubing. Such an arrangement allows the heat to be transferred away from the electronic components and to the ambient environment. Horizontal tubing, when possible, is often preferred because it minimizes pressure losses within a flow.

196. To the extent this limitation was not disclosed or taught based on Ryu in view of the knowledge, education, experience, and training of a POSA, it would have been obvious in view of Batchelder. I have already discussed Batchelder in the context of this claim limitation and I adopt that prior discussion here.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

197. As I have already discussed, this portion of Claim 17 is disclosed or rendered obvious by Ryu (except for the "single receptacle" aspect of the "reservoir" and the "curved blades"); I adopt that prior analysis here.

198. To the extent this limitation was not disclosed or taught in Ryu, it would have been obvious to a POSA based on her experience, education, and training. Using a pump to circulate a cooling liquid through a reservoir and a heat radiator with a motor and a curved-blade impeller that is positioned in the reservoir is routinely encountered by a POSA who works on thermal management of electronics. In fact, I have worked with such systems many times in my research and teaching activities, as I have already discussed. A POSA would have been motivated to incorporate curved impeller blades within a reservoir because they provide flow and pressure characteristics that have advantages over straight impeller blades.

199. To the extent this was not disclosed or taught to a POSA, it would have been obvious in view of Batchelder, which shows a pump that has an impeller that is positioned in the reservoir as I have already discussed. I adopt that discussion here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

200. As I have already discussed, this portion of Claim 17 was disclosed or taught by Ryu; I adopt that prior analysis here.

201. To the extent this was not disclosed or taught from Ryu, it would have been obvious to a POSA based on her experience, education, and training. Fans are ubiquitous in their use directing air through heat radiators. Often air fans are operated with a motor separate for the motor of the liquid pump. A POSA would have been motivated to use a separate motor because air fans are typically purchased with their own locomotive system. Furthermore, separate motors allow the air fan and the liquid pump to be controlled separately based on the heating requirements of the system. This allows impeller speeds to be modulated independently, reducing noise and wasted energy. Furthermore, separate motors provide a safety measure – if one motor fails the other motor will continue to operate and provide cooling.

202. To the extent this was not disclosed or taught to a POSA, it would have been obvious in view of Batchelder, which shows a pump that has an impeller that is positioned in the reservoir as I have already discussed. I adopt that discussion here. In addition, the torque requirements for an air fan and a liquid pump tend to be very different and would have preferably been driven by different motors generating different torques from a POSA's perspective. These factors would have motivated a POSA to use two different motors.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

203. As I have already discussed, Ryu discloses a pump activated to circulate cooling liquid between the upper and lower chambers of the reservoir; I adopt that prior analysis here.

204. To the extent this claim was not disclosed or taught by Ryu, it would have been obvious to a POSA based on her experience, education, and training. A POSA would have found it routine to use a pump to circulate cooling liquid between upper and lower chambers of a reservoir. I have used such fluid pumps multiple times myself, as I have already discussed. A POSA would have been motivated to circulate liquid between the upper and lower chambers of the reservoir because it would be an efficient way to deliver liquid to the vicinity of the heat generating device.

205. If this claim was not disclosed or taught with Ryu in view of the experience, education, and training of a POSA, it would have been obvious in view of Batchelder. Batchelder discloses a pump that circulates cooling liquid between upper and lower chambers of a reservoir, as I have already discussed. I adopt that prior analysis here.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

206. To the extent this limitation was not disclosed or taught based on Ryu alone, then it would have been obvious to a POSA based on her experience, education, and training. The circulating of cooling liquid between two chambers through a single passageway is a trivial design exercise for a POSA working on the thermal management of electronics, as

I have already discussed. A POSA would have been motivated to circulate cooling liquid between the upper and lower chambers through a single passageway because it is an efficient way to deliver fluid to the vicinity of the heat-generating component.

207. To the extent it was not disclosed or taught based on Ryu and the knowledge of a POSA, it would have been obvious in view of Batchelder. I have already analyzed Batchelder against this claim and I adopt that prior analysis here.

F. Ground 6 – Batchelder in View of Shin

208. It is my opinion that Batchelder, in view of Shin and in view of the knowledge of a POSA, renders claims 17 and 19 of the '362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

209. The preamble of claim 17 was disclosed or taught by the combination of Batchelder and Shin, or by each reference individually, as I have already explained. I adopt that prior analysis here.

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

210. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

… the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

211. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

… the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

212. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

213. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

214. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

215. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

216. This claim was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

217. This claim was disclosed or taught by the combination of Batchelder and Shin, as I have already explained. I adopt that prior analysis here.

G. Ground 7 – Batchelder in View of Ryu

218. It is my opinion that Batchelder, in view of Ryu and in view of the knowledge of a POSA, renders claims 17 and 19 of the '362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

219. The preamble of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

220.

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

221. This limitation portion of claim 17 is disclosed or rendered obvious by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

…the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

222. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

…the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

223. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

224. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

225. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

226. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

227. This claim was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

228. This claim was disclosed or taught by the combination of Batchelder and Ryu, as I have already explained. I adopt that prior analysis here.

H. Ground 8 – Batchelder in View of Wu

229. It is my opinion that Batchelder, in view of Wu and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

230. The preamble of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

231. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

…the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

232. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

…the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

233. This limitation portion of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;

234. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

235. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

236. This limitation of claim 17 was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

237. This claim was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

238. This claim was disclosed or taught by the combination of Batchelder and Wu, as I have already explained. I adopt that prior analysis here.

I. Ground 9 – Yu in View of Wu

239. It is my opinion that Yu, in view of Wu and in view of the knowledge of a POSA, renders claims 17 and 19 of the ’362 patent invalid.

Claim 17 preamble: A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:

240. The preamble of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

17(a) separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard…….

241. This limitation portion of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

… the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and separated by at least a horizontal wall, …

242. This limitation portion of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

…the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, the heat exchanging interface being removably coupled to the reservoir such that an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir.

243. This limitation portion of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

17(b) positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location.

244. This limitation of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

17(c) activating a pump to a [sic] circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and

245. This limitation portion of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

17(d) activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.

246. This limitation portion of claim 17 was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

Claim 18: The method of claim 17 wherein activating the pump includes circulating cooling liquid between the upper and lower chambers of the reservoir

247. This claim was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

Claim 19: The method of claim 18, wherein circulating the cooling liquid between the upper and lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.

248. This claim was disclosed or taught by Yu and Wu, as I have already explained. I adopt that prior analysis here.

VIII. ANALYSIS OF VALIDITY OF THE ’196 PATENT PURSUANT TO 35 U.S.C. §§ 102 AND/OR 103

249. I have considered the prior art and their combinations in forming my opinions on invalidity of claims 1, 2, and 13 of the ’196 patent pursuant to §§ 102 and/or 103:

- JP 2002-151638 (Shin)
- KR 2003-0031027 (Ryu)
- U.S. 7,544,049 (Koga)
- U.S. Patent Application 2006/0185830 (Duan)

250. It is my opinion that claims 1, 2, and 13 of the ’196 patent are invalid by anticipation or obviousness under the following grounds:

Ground	Combination
1	Duan (claims 1, 2, and 13)
2	Shin in view of Duan (claims 1, 2, and 13)
3	Ryu in view of Duan (claims 1, 2, and 13)
4	Koga in view of Duan (claims 1, 2, and 13)

A. Ground 1 - Duan

251. It is my opinion that Duan, either alone or in view the knowledge of a POSA, renders the claims 1, 2, and 13 of the ’196 patent invalid.

Claim 1 (preamble) A liquid cooling system for cooling a heat-generating component of a computer, comprising

A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy. It is my understanding that the preamble to claim 1 is not limiting. But to the extent it is limiting, Duan discloses or teaches a liquid cooling system for cooling a heat-generating component of a computer. Duan identifies a computer chip as item 200 and explicitly discusses its role in cooling computer systems (including the discussion of prior art), for example:

> [0005] **FIG. 1** shows a perspective view of a prior art liquid-cooling heat dissipation system **100***a*. As shown in this figure, the liquid-cooling heat dissipation system **100***a* comprises a heat dissipation stage **10***a*, a water outlet **101***a* and a water inlet **102***a* on both ends of the heat dissipation system stage **10***a*, respectively, a duct **103***a* connected between the water inlet **102***a* and a water outlet **201***a* of a water pump **20***a*, a duct **104***a* connected between the water outlet **101***a* and a water inlet **301***a* of a cooling stage **30***a*, which is composed of a plurality of heat-dissipating fins **303***a*. The cooling stage **30***a* comprises a water outlet **302***a* connected to a water inlet **401***a* of a water tank **40***a* through a duct **402***a*. The water tank **40***a* comprises a water outlet connected to the water inlet **202***a* of the water pump **20***a*, thus forming the liquid-cooling heat dissipation system **100***a*. During operation, the water pump **20***a* conveys cool water to the heat dissipation stage **10***a* for heat exchanging into hot water. Afterward, hot water flows to the cooling stage **30***a* through the duct **104***a* for heat exchanging into cool water there and cool water flows back to the water tank **40***a* through the duct **304***a*. The above operations are repeated for cyclic heat exchange.

Duan [0005]

liquid cooling cyclic mechanism **100**, which is used for the heat dissipation of a CPU **200** and composed of the cooling plate module **10** and a water tank module **20** connected with the cooling plate module **10** through ducts. The cooling plate module **10** comprises a cooling plate **1** and a liquid driving module **2**. The cooling plate **1** comprises a heat absorbing face **11** on bottom thereof and being in contact with a heat source. A plurality of heat-dissipating plates **12** are formed on top face of the cooling plate **1** and can be arranged in longitudinal or transverse manner. A runner is defined between the plurality of heat-dissipating plates **12** and forms a closed loop.

Duan [0022]

CPU **200** with the heat absorbing face **11** being in contact with the CPU **200** for heat dissipating the CPU **200**.

Duan [0026]

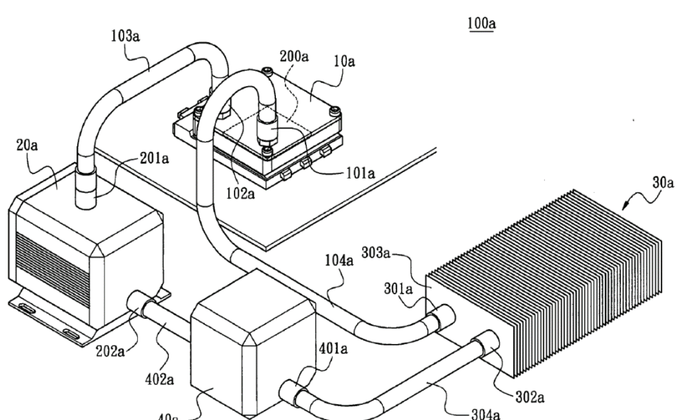


FIG. 1
PRIOR ART

Duan Figure 1

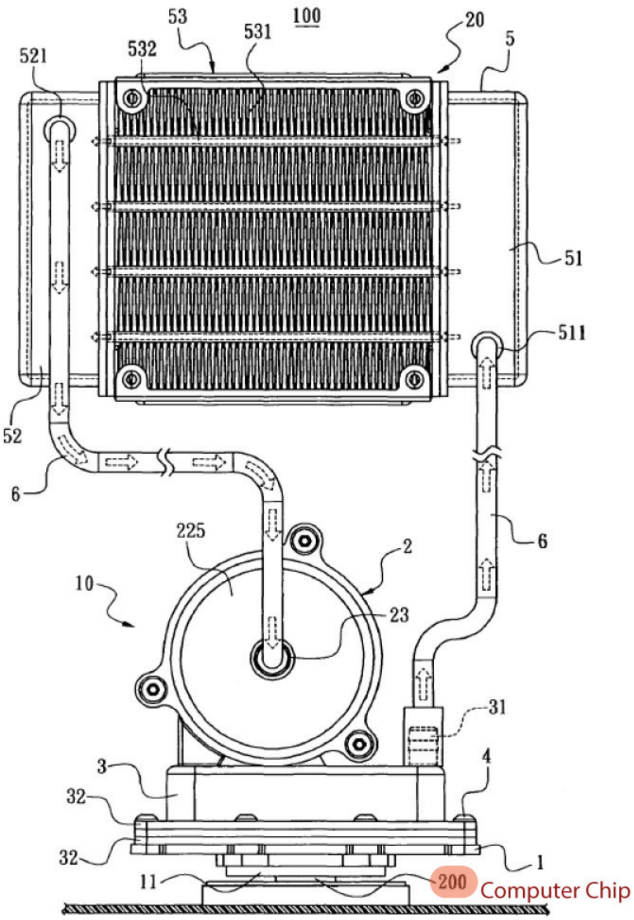


FIG. 6

Duan, Figure 6

1(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

252. Duan discloses the claimed reservoir configured to circulate a cooling liquid therethrough. The following image outlines the region of Duan that is the claimed reservoir. The throughflow of cooling liquid is indicated by the arrows in the following image. A POSA would have been motivated to utilize a reservoir for circulating a cooling liquid because reservoirs are efficient and simple means of routing fluid to a heated region and thus facilitate heat removal from that region.

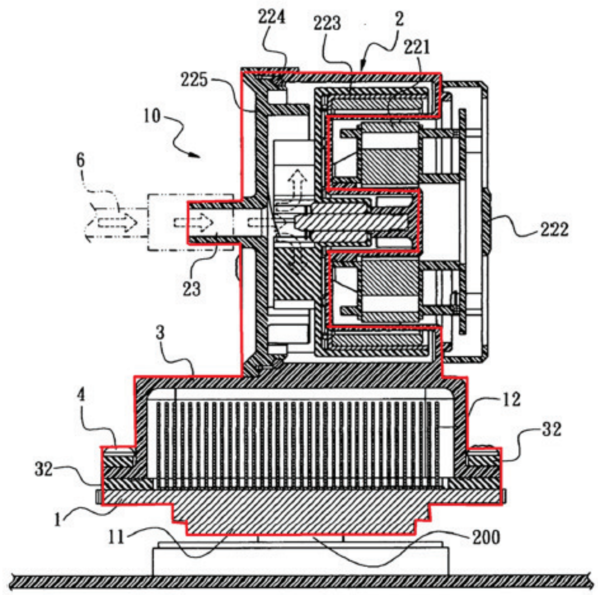


FIG. 7

Duan Figure 7

Color	Duan Element	'196 Limitation
Dark red	Accommodation chamber 21	Reservoir configured to circulate a cooling liquid there-through
Light blue	Cap 3	
Dark blue	Cooling plate 1	
Green	Lower cover 225	

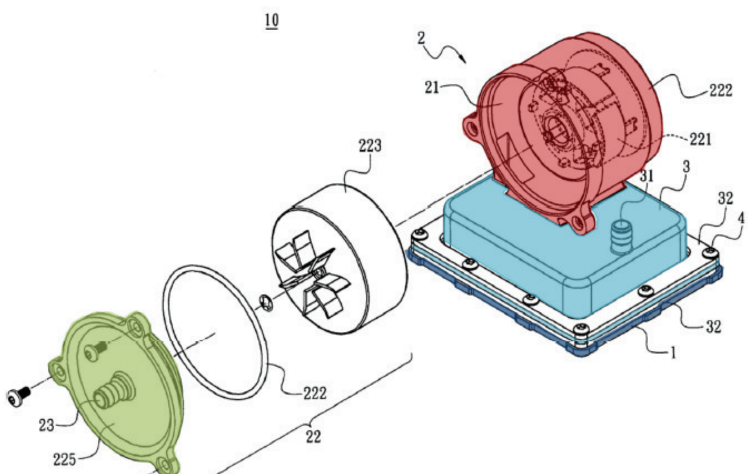


FIG. 3

Duan, Figure 3

1(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being position on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes:

253. Duan includes a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis. The impeller of Duan is positioned on one side of the chassis and a stator of the pump is positioned on the opposite side of the chassis, as shown in the figures that follow.

254. In this image, the rotor (orange) and the stator (yellow) are on opposite sides of the double-sided chassis (red).

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator
Dark red	Accommodation chamber 21	Double-sided chassis
Orange	Impeller stage 223	Impeller
Green	Lower cover 225	Impeller cover
Light Blue	Cap 3	Thermal exchange chamber
Dark Blue	Cooling plate 1	Heat-exchanging interface

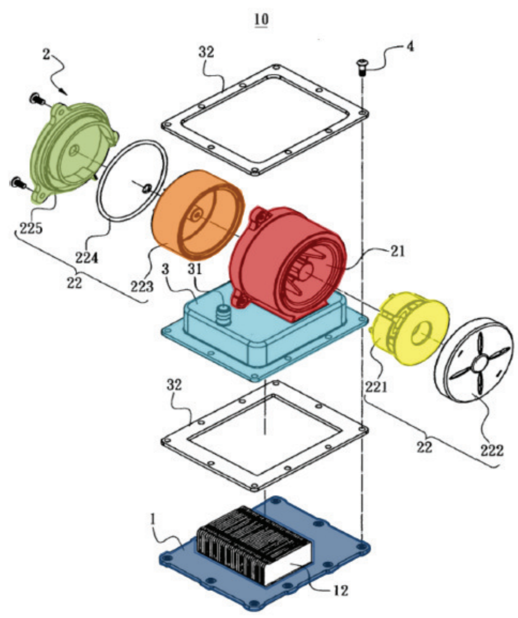
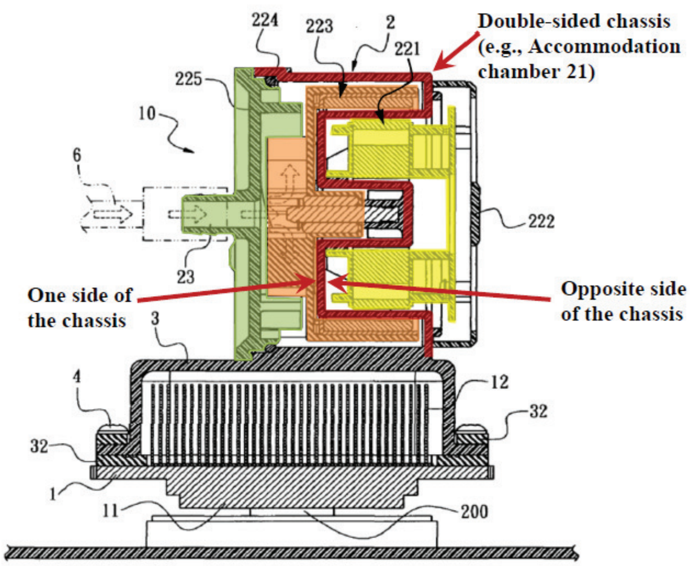


FIG. 2

Duan, Figure 6

255. The following section view also shows the stator (yellow) and impeller (orange) separated by the double-sided chassis (red). A POSA would have been motivated to use a pump chamber housing an impeller and defined by an impeller cover and a double-sided chassis with the impeller and stator positioned on opposite sides of the chassis. Such a design isolates the stator from the impeller and facilitates the routing of fluid to the heated region

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator of the pump
Dark red	Accommodation chamber 21	Double-sided chassis
Orange	Impeller stage 223	Impeller
Green	Lower cover 225	Impeller cover



Duan Figure 7

1(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

256. Duan also discloses an impeller cover (225) that has been colored green. That cover is positioned below the center of the impeller to enable cooling liquid to flow into the center

of the pump chamber (21). A POSA would have been motivated to incorporate an impeller cover positioned below a center of the impeller and configured to enable a cooling fluid to flow into the center of the pump chamber. Such an arrangement is a simple and hydraulically efficient way to route fluid and reduce fluid connections and to improve heat transfer.

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator
Dark red	Accommodation chamber 21	Double-sided chassis
Orange	Impeller stage 223	Impeller
Green	Lower cover 225	Impeller cover

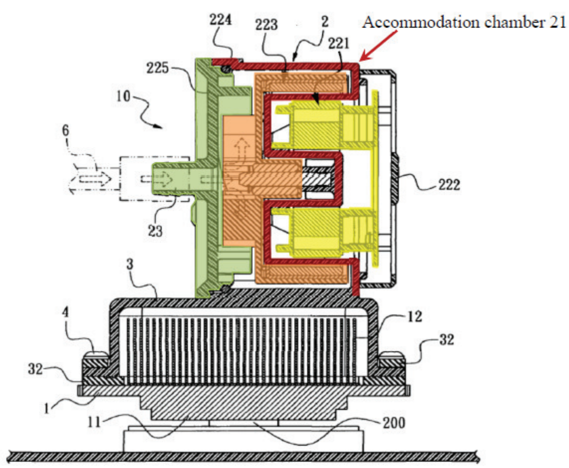
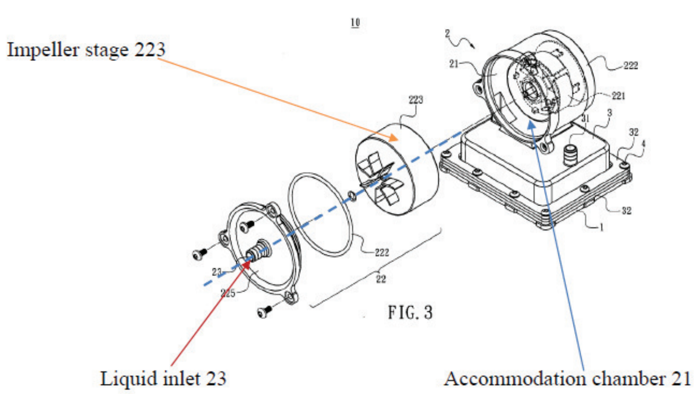


FIG. 7

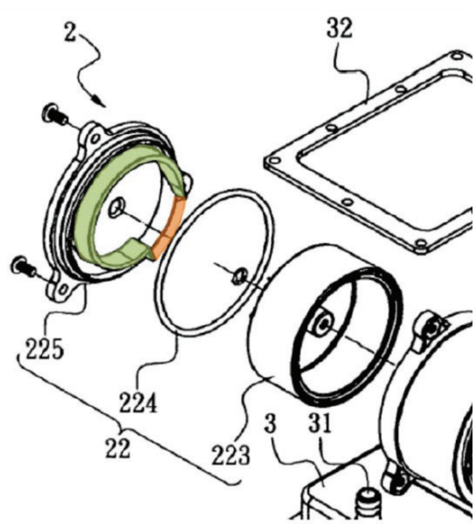
Duan, Figure 7



Duan, Figure 3

1(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller,

257. Duan further teachers an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller (shown in orange below). A POSA would have been motivated to position an outlet tangential to the circumference of the impeller because this reduces hydraulic resistance and improves the pump performance



Duan, Figure 2

258. This outlet is assembled to align with another port on the accommodation chamber 21, as shown here.

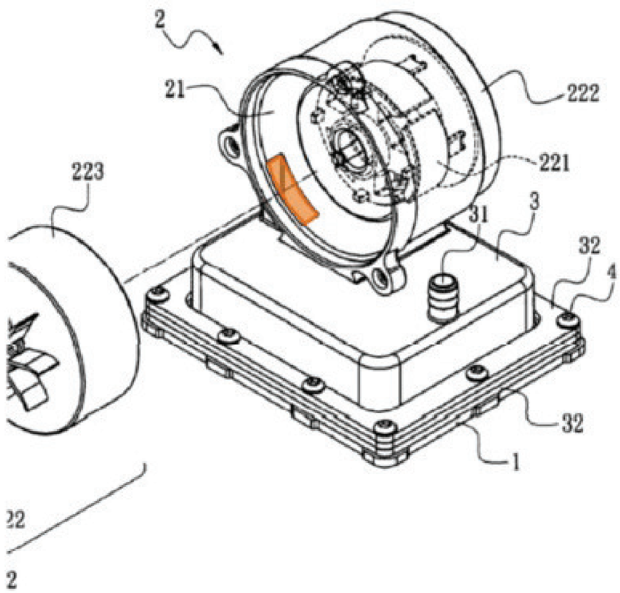


FIG. 3

Duan, Figure 3

1(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

259. Duan also teaches a thermal exchange chamber (3) that is configured to be disposed between the pump chamber (210) and a heat generating component (200).

260. Duan discusses both chambers, for example, in the following. The referenced accommodation chamber is the claimed pump chamber and cap (3) creates the claimed thermal exchange chamber.

driving module. The liquid driving module includes an accommodation chamber and a liquid driving unit used to driving cooling liquid. The liquid driving module includes a liquid inlet communicated to the accommodation chamber and a first liquid outlet is communicated to the bottom of the accommodation chamber. A cap encloses the first liquid outlet and a second liquid outlet is defined on the cap. The cooling plate is assembled with the cap to define a closed space therein and the first liquid outlet is corresponding to the heat-dissipating plates.

Duan [0009]

[0023] With reference to **FIGS. 2, 3** and **4**, the liquid driving module **2** comprises an accommodation chamber **21** and a liquid driving unit **22** located in the accommodation chamber **21** and used to driving the cool liquid. The liquid driving unit **22** comprises a coil stage **221**, an upper cover **222**, an impeller stage **223**, a sealing washer **224** and a lower cover **225**. The lower cover **225** comprises a liquid inlet **23** communicated with the accommodation chamber **21**. A first liquid outlet **24** is communicated to the bottom of the accommodation chamber **21** and is enclosed by a cap **3**. A second liquid outlet **31** is defined on the cap **3**. The cooling plate **1** is assembled with the cap **3** to define a closed space therein and the first liquid outlet **24** is corresponding to the heat-dissipating plates **12**. In the present invention, the liquid driving module **2** can be reciprocating pump, centrifugal pump or axial-flow pump.

Duan [0023]

[0027] With reference to **FIGS. 7 and 8**, during operation of the present invention, the cool liquid in the water tank **20** is conveyed to the accommodation chamber **21** through the duct **6** and the liquid inlet **23** of the cooling plate module **10** and driven by the liquid driving unit **22**. The cool liquid then flows to the cap **3** through the first liquid outlet **24** for heat dissipating the heat-dissipating plates **12** in the cap **3**. More particularly, the cool liquid is heat exchanged with the heat-dissipating plates **12** into hot liquid. The hot liquid then flows to the liquid entrance region **51** of the water tank **20** through the second liquid outlet **31** of the cooling plate module **10** and another duct **6**.

Duan [0027]

> [0029] **FIG. 9** shows another preferred embodiment of the present invention, the liquid driving module **2** is integrally formed at center of the cap **3** such that the cool liquid flowing into the accommodation chamber **21** will directly flow out of the first liquid outlet **24** and flush the heat-dissipating plates **12** to heat dissipate the heat-dissipating plates **12** with enhanced efficiency.

Duan [0029]

> a liquid driving module comprising an accommodation chamber and a liquid driving unit used to driving a cooling liquid, the liquid driving module comprising a liquid inlet communicated to the accommodation chamber and a first liquid outlet communicated to a bottom of the accommodation chamber; a cap enclosing the first liquid outlet and a second liquid outlet being defined on the cap;
>
> wherein the cooling plate is assembled with the cap to define a closed space therein and the first liquid outlet is corresponding to the heat-dissipating plates.

Duan, Claim 1

261. The following image highlights the thermal exchanger chamber.

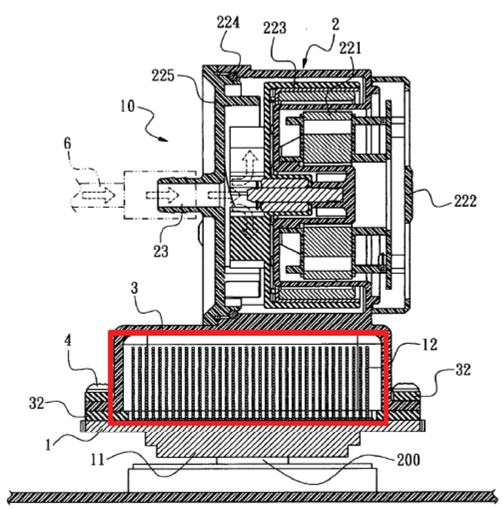
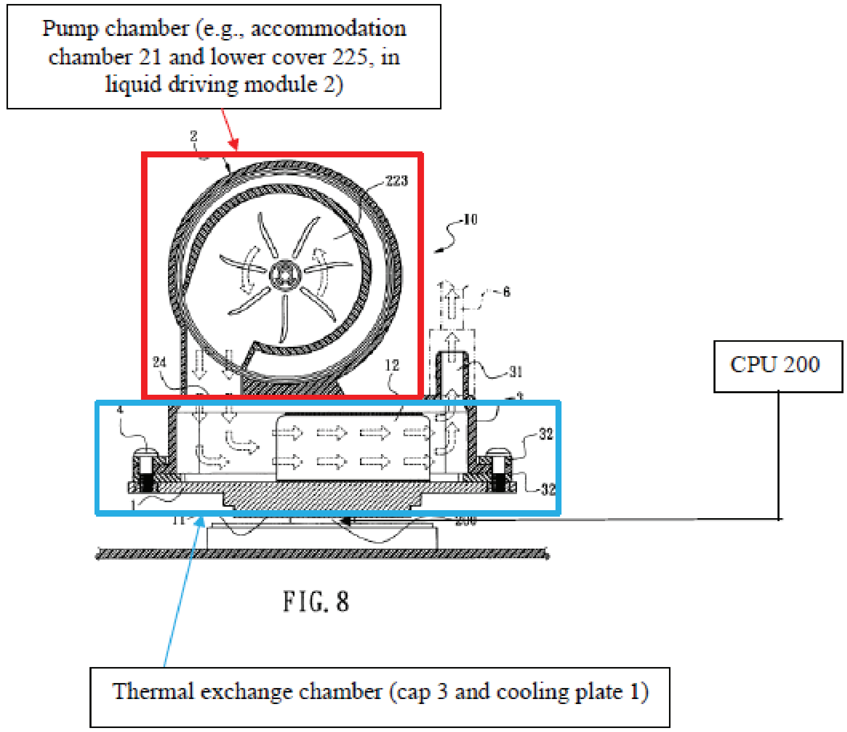


FIG. 7

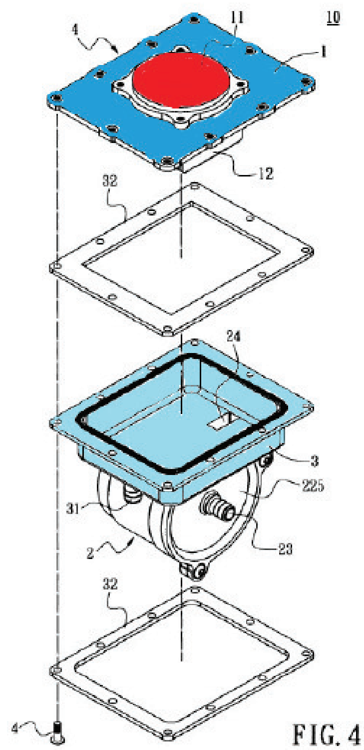
Duan, Figure 7



Duan, Figure 8

262. An inverted orientation of the thermal exchange chamber is provided below. The thermal exchange chamber is identified as item 3. The surface that thermally couples to the heat-generating electronics is item 11, colored in red.

Color	Duan Element	'196 Limitation
Light Blue	Cap 3	Thermal Exchange Chamber
Dark Blue	Cooling plate 1	Heat exchanging interface
Red	Heat-absorbing face 11	Heat exchanging interface



Duan, Figure 4

263. Using a similar color scheme to identify the thermal exchange chamber, the following image is provided. A POSA would have been motivated to incorporate a thermal exchange chamber disposed between the pump chamber and the heat-generating component because the close proximity of the thermal exchange chamber and the heat-generating component would reduce thermal resistance and lower temperatures.

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator
Dark red	Accommodation chamber 21	Double-sided chassis
Orange	Impeller stage 223	Impeller
Green	Lower cover 225	Impeller cover
Light Blue	Cap 3	Thermal exchange chamber
Dark Blue	Cooling plate 1	Heat-exchanging interface

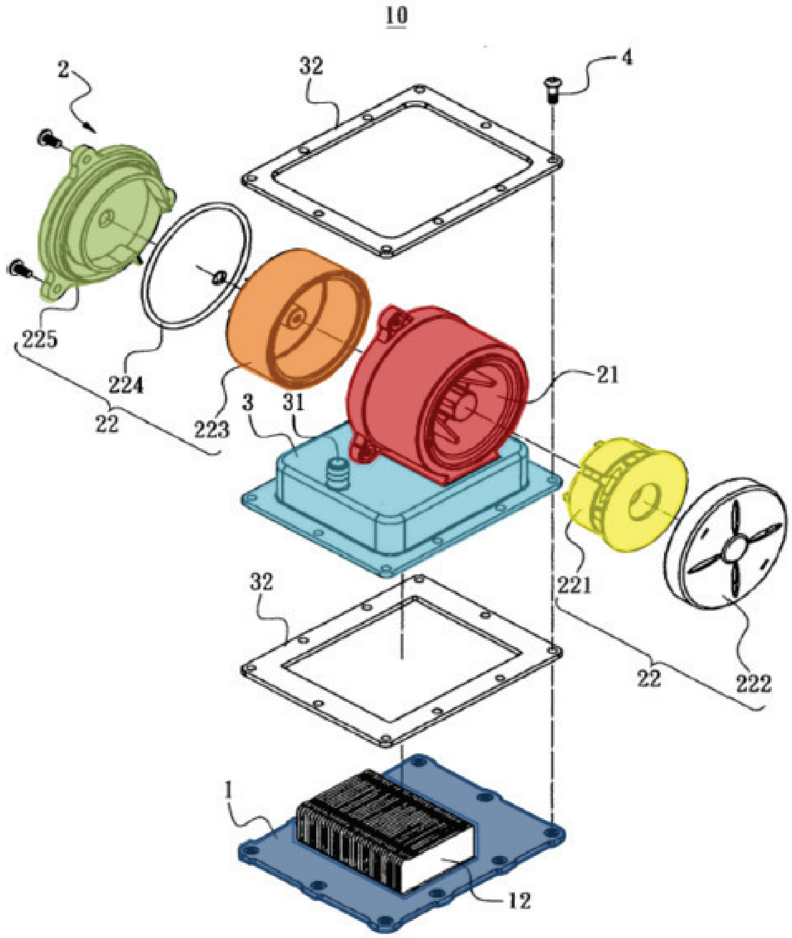


FIG. 2

Duan, Figure 2

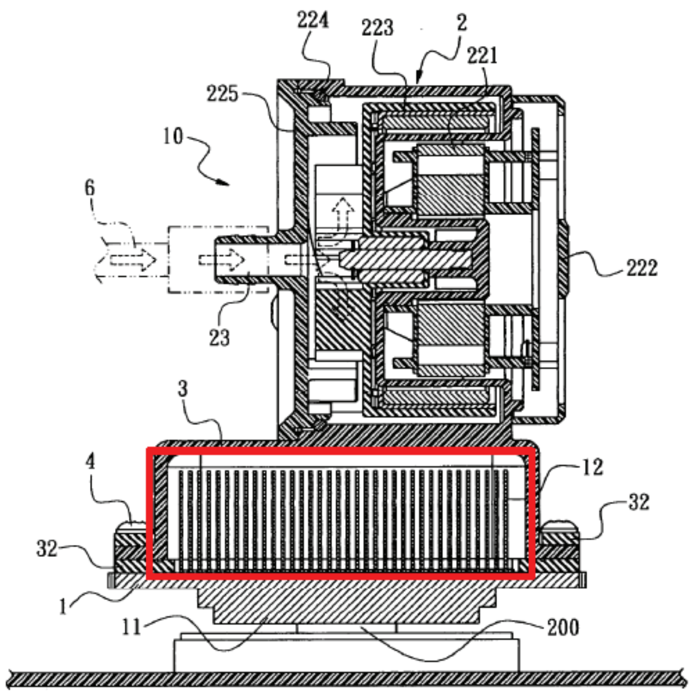


FIG. 7

Duan, Figure 7

1(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of channels that direct the flow of the cooling liquid within the thermal exchange chamber;

264. Duan also discloses a heat-exchanging interface that forms a boundary wall of the thermal exchange chamber. The heat-exchanging interface has an outer surface configured to be placed in thermal contact with a heat-generating component and an inner surface that defines a plurality of channels that direct the flow of cooling liquid within the

thermal exchange chamber. The channels that direct fluid are plates 12 that are described in the following:

liquid cooling cyclic mechanism **100**, which is used for the heat dissipation of a CPU **200** and composed of the cooling plate module **10** and a water tank module **20** connected with the cooling plate module **10** through ducts. The cooling plate module **10** comprises a cooling plate **1** and a liquid driving module **2**. The cooling plate **1** comprises a heat absorbing face **11** on bottom thereof and being in contact with a heat source. A plurality of heat-dissipating plates **12** are formed on top face of the cooling plate **1** and can be arranged in longitudinal or transverse manner. A runner is defined between the plurality of heat-dissipating plates **12** and forms a closed loop.

Duan [0022]

[0027] With reference to **FIGS. 7 and 8**, during operation of the present invention, the cool liquid in the water tank **20** is conveyed to the accommodation chamber **21** through the duct **6** and the liquid inlet **23** of the cooling plate module **10** and driven by the liquid driving unit **22**. The cool liquid then flows to the cap **3** through the first liquid outlet **24** for heat dissipating the heat-dissipating plates **12** in the cap **3**. More particularly, the cool liquid is heat exchanged with the heat-dissipating plates **12** into hot liquid. The hot liquid then flows to the liquid entrance region **51** of the water tank **20** through the second liquid outlet **31** of the cooling plate module **10** and another duct **6**.

Duan [0027]

265. The heat exchanging surface disclosed by Duan is illustrated in the following image.

Color	Duan Element	'196 Limitation
Light Blue	Cap 3	Thermal Exchange Chamber
Dark Blue	Cooling plate 1	Heat exchanging interface
Red	Heat-absorbing face 11	Heat exchanging interface

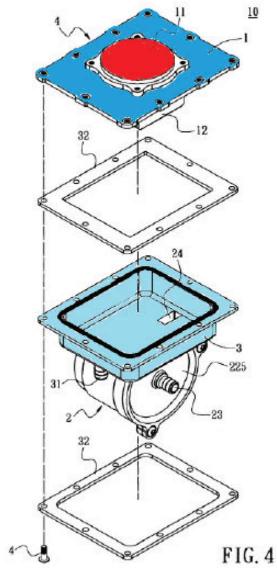


FIG. 4

Duan, Figure 4

Color	Duan Element	'196 Limitation
Purple	Heat-dissipating plates 12	Fins defining the plurality of channels

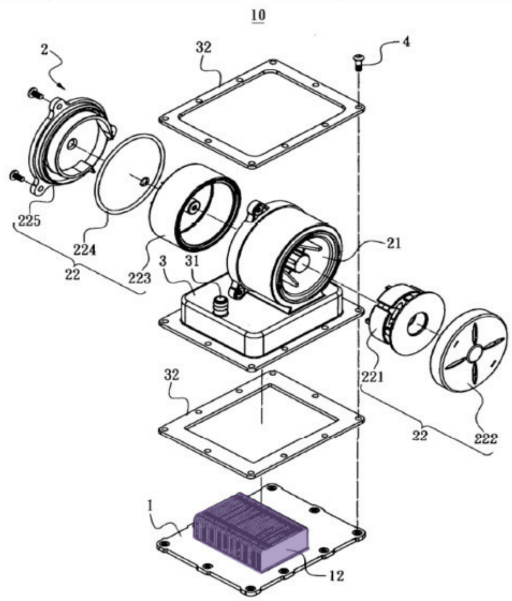


FIG. 2

Duan, Figure 2

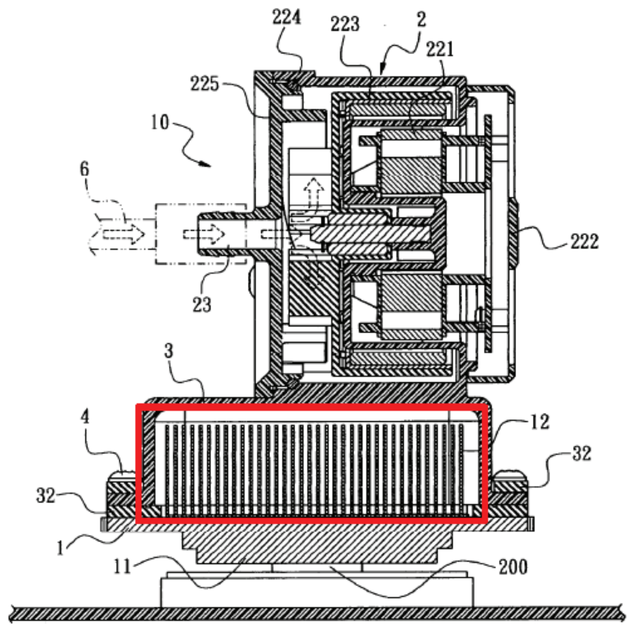


FIG. 7

Duan, Figure 7

266. The heat exchanging interface is designed to be placed in contact with a heat-generating component, as shown here (and shown in red in prior images). A POSA would have been motivated to use a heat-exchanging interface that is a boundary wall of the thermal exchange chamber and in thermal contact with a heat-generating component and with an inner surface that has a plurality of channels to direct the flow. The close proximity of the heat-exchange interface to the thermal exchange chamber and to the heat-generating component reduces the thermal resistance and lowers the temperature. In addition, use of channels increases the convective heat transfer and also reduces temperatures.

> liquid cooling cyclic mechanism **100**, which is used for the heat dissipation of a CPU **200** and composed of the cooling plate module **10** and a water tank module **20** connected with the cooling plate module **10** through ducts. The cooling plate module **10** comprises a cooling plate **1** and a liquid driving module **2**. The cooling plate **1** comprises a heat absorbing face **11** on bottom thereof and being in contact with a heat source. A plurality of heat-dissipating plates **12** are formed on top face of the cooling plate **1** and can be arranged in longitudinal or transverse manner. A runner is defined between the plurality of heat-dissipating plates **12** and forms a closed loop.

Duan [0022]

> a cooling plate comprising a heat absorbing face on bottom thereof and being in contact with a heat source, and a plurality of heat-dissipating plates on top face of the cooling plate;

Duan, Claim 1

1(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

267. Duan also discloses a heat radiator that is adapted to pass cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir by fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid. These features are discussed both in the discussion of prior art as well as in the description of the invention. A POSA would have been motivated to use a radiator adapted to pass cooling liquid therethrough with the radiator coupled to the reservoir. Such an arrangement allows the heat from the

heat-generating component to be removed from the vicinity of the heat-generating location and transferred to the ambient environment in an efficient manner.

> [0005] **FIG. 1** shows a perspective view of a prior art liquid-cooling heat dissipation system **100***a*. As shown in this figure, the liquid-cooling heat dissipation system **100***a* comprises a heat dissipation stage **10***a*, a water outlet **101***a* and a water inlet **102***a* on both ends of the heat dissipation system stage **10***a*, respectively, a duct **103***a* connected between the water inlet **102***a* and a water outlet **201***a* of a water pump **20***a*, a duct **104***a* connected between the water outlet **101***a* and a water inlet **301***a* of a cooling stage **30***a*, which is composed of a plurality of heat-dissipating fins **303***a*. The cooling stage **30***a* comprises a water outlet **302***a* connected to a water inlet **401***a* of a water tank **40***a* through a duct **402***a*. The water tank **40***a* comprises a water outlet connected to the water inlet **202***a* of the water pump **20***a*, thus forming the liquid-cooling heat dissipation system **100***a*. During operation, the water pump **20***a* conveys cool water to the heat dissipation stage **10***a* for heat exchanging into hot water. Afterward, hot water flows to the cooling stage **30***a* through the duct **104***a* for heat exchanging into cool water there and cool water flows back to the water tank **40***a* through the duct **304***a*. The above operations are repeated for cyclic heat exchange.

Duan [0005]

> [0028] The hot liquid flowing into the liquid entrance region **51** of the water tank **20** will be conveyed to each runner **532** and heat exchanged with the heat-dissipating fins **531** into cool liquid. The cool liquid flows to the liquid exit region **52** of the water tank **20** and then flows to the cooling plate module **10** through the duct **6** connected to the liquid exit region **52**, thus performing cyclic heat exchange.

Duan [0028]

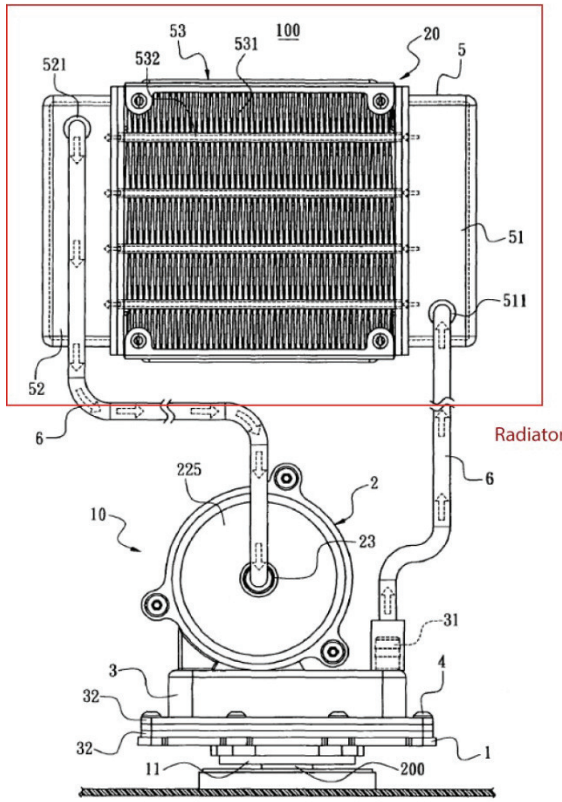


FIG. 6

Duan, Figure 6

1(h) a first passage fluidly coupling the pump chamber and the thermal exchange chamber, wherein the first passage is configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber.

268. Duan discloses the claimed first passage that fluidly couples the pump chamber and the thermal exchange chamber, wherein the first passage is configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber, as shown in the following images. A POSA would have been motivated to utilize a passage to fluidly couple the

pump chamber and the thermal exchange chamber. This allows the cooling liquid to pass from the pump chamber to the thermal exchange chamber. As can be seen below, the first passage of Duan (24) is further configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between the first end and the second end of the thermal exchange chamber (blue arrow indicating the flow from the outlet of the pump chamber into the thermal exchange chamber). This flow between the first end and the second end of the thermal exchange chamber allows the cooling fluid to more directly impact the heat transfer region and facilities a more uniform temperature.

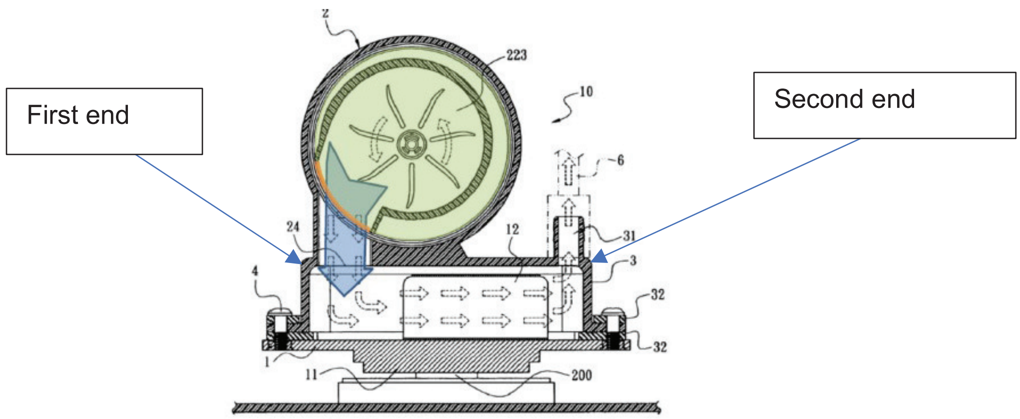


FIG. 8

Duan Figure 8

Claim 2: wherein the thermal exchange chamber includes at least one second passage configured to direct the cooling liquid out of the thermal exchange chamber, the at least one second passage is positioned at either a first end or a second end of the thermal exchange chamber.

269. Duan discloses the limitations in claim 2 as shown below. A POSA would have been motivated to use a thermal exchange chamber that includes a second passage configured

to direct cooling liquid out of the thermal exchange chamber so that the fluid can circulate between the two chambers and draw heat away from the heat-generating component and distribute the heat to the ambient environment.

> **[0026]** In the present invention, during the assembling of the liquid cooling cyclic mechanism **100**, the liquid inlet **23** of the cooling plate module **10** is communicated to the liquid outlet **521** of the liquid exit region **52** of the water tank **20** through duct **6**. Moreover, the second liquid outlet **31** of the cooling plate module **10** is communicated to the liquid inlet **511** of the liquid entrance region **51** of the water tank **20** through duct **6**, thus forming the liquid cooling cyclic mechanism **100** with continuous cycles. Thereafter, the liquid cooling cyclic mechanism **100** is assembled to the
>
> CPU **200** with the heat absorbing face **11** being in contact with the CPU **200** for heat dissipating the CPU **200**.

Duan [0026]

Color	Duan Element	'196 Patent Limitation
Pink	Second liquid outlet 31	Second passage
Light blue	Cap 3	Thermal exchange chamber
Dark blue	Cooling plate 1	Heat exchanging interface

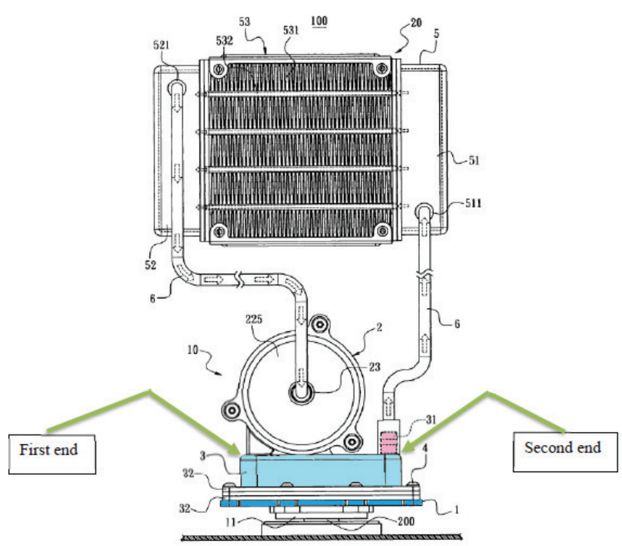
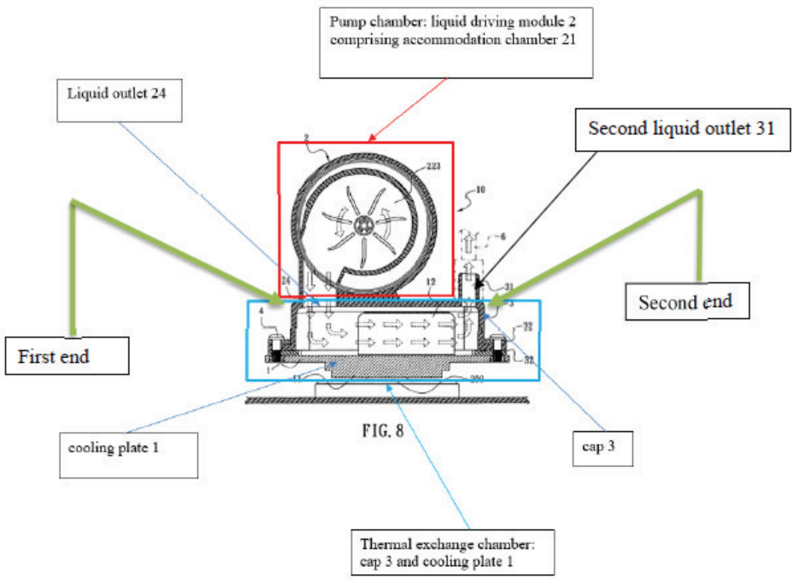


FIG. 6

Duan Figure 6

> [0027] With reference to **FIGS. 7 and 8**, during operation of the present invention, the cool liquid in the water tank **20** is conveyed to the accommodation chamber **21** through the duct **6** and the liquid inlet **23** of the cooling plate module **10** and driven by the liquid driving unit **22**. The cool liquid then flows to the cap **3** through the first liquid outlet **24** for heat dissipating the heat-dissipating plates **12** in the cap **3**. More particularly, the cool liquid is heat exchanged with the heat-dissipating plates **12** into hot liquid. The hot liquid then flows to the liquid entrance region **51** of the water tank **20** through the second liquid outlet **31** of the cooling plate module **10** and another duct **6**.

Duan [0027]



Duan Figure 8

Claim 10 Preamble A liquid cooling system for cooling a heat-generating component of a computer, comprising;

270. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including,

271. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being positioned on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes,

272. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

273. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller;

274. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

275. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of parallel channels that are configured to direct the flow of the cooling liquid within the thermal exchange chamber;

276. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

277. For reasons already discussed in relation to claim 1, Duan discloses the preamble of this claim. I adopt that prior analysis here.

10(h) a set of four mounting legs configured to secure the heat-exchanging interface to a heat-generating component of a computer.

278. Duan discloses or teaches this limitation, as evident by the cited prior art, that is reproduced here.

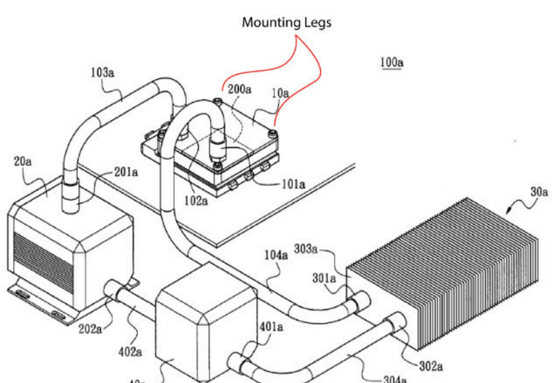


FIG. 1
PRIOR ART

Duan Figure 1

279. To the extent Duan does not teach or disclose a set of four mounting legs, it would have been obvious to a POSA to use mounting legs. In fact, the admitted prior art in the asserted patents disclose such mounting legs, as shown above. Retaining frame 3 has four legs which are matched with four legs of brace 6. A POSA would have been motivated to use four legs to secure the thermal exchange interface to the heat-generating component because the legs provide a uniform contact at the interface and thereby reduces thermal resistance.

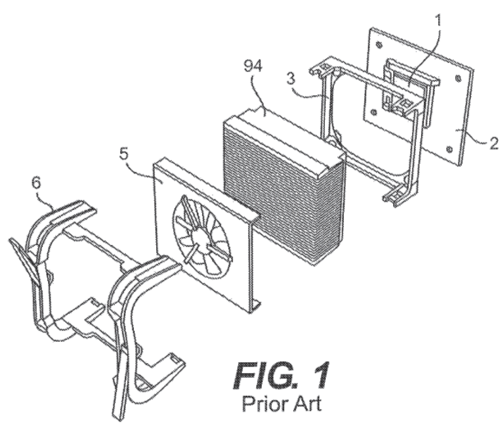


FIG. 1
Prior Art

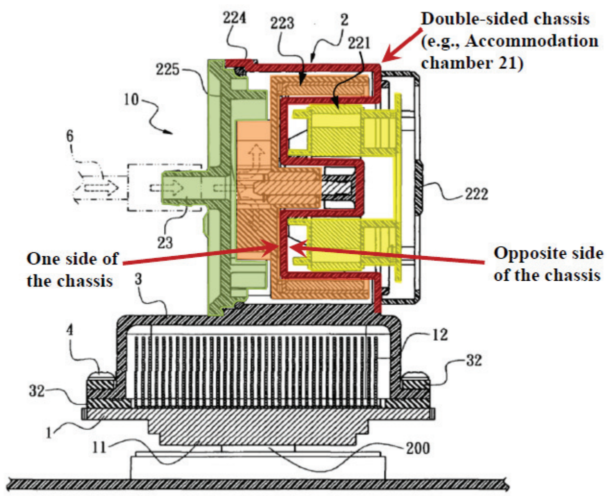
’196 patent, Figure 1

Claim 13: The liquid cooling system of claim 10, wherein the double-sided chassis defines a recess configured to house the stator.

280. Duan discloses or teaches this limitation. Duan teaches a double-sided chassis that defines a recess that is configured to house the stator, as shown here, where the chassis is highlighted in red. A POSA would have been motivated to use a double sided chassis

with a recess to house the stator because this arrangement effectively isolates the stator from the impeller and helps the pump efficiently direct fluid to the heated region where is removes heat and transfers the heat to the ambient environment.

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator of the pump
Dark red	Accommodation chamber 21	Double-sided chassis
Orange	Impeller stage 223	Impeller
Green	Lower cover 225	Impeller cover



Duan Figure 7

Color	Duan Element	'196 Limitation
Yellow	Coil stage 221	Stator
Red	Back portion of accommodation chamber 21	Recess defined by Double-sided chassis

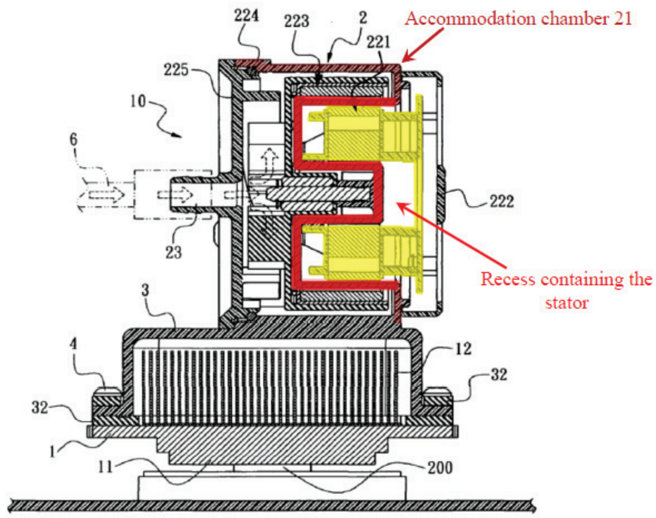


FIG. 7

Duan Figure 7

B. Ground 2 – Shin in View of Duan

281. It is my opinion that Shin in view of Duan renders claims 1, 2, and 13 of the '196 patent invalid.

Claim 1 (preamble) A liquid cooling system for cooling a heat-generating component of a computer, comprising

282. It is my understanding that the preamble to claim 1 is not limiting. But, to the extent the preamble is determined to be limiting, Shin teaches this preamble. Shin discloses g a liquid cooling system for cooling a heat-generating component of a computer.

283. The title of Shin is "COOLING DEVICE FOR ELECTRONIC EQUIPMENT"

284. The abstract of Shin clearly states that it is a liquid cooling system. The abstract states "A cooling structure for compactly mounting a liquid cooled heat sink and pump inside a case."

285. Shin makes clear that it is intended to be used for cooling heat-generating components of a computer; as evidenced by the following representative but non-exhaustive passages.

> [Means for solving the problem] To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink.

Shin [0007]

> [0008] Furthermore, the pump is secured to the top part of the liquid cooled heat sink, forming a structure that allows the pump and liquid cooled heat sink to be handled as an integral structure.
> [0009] Furthermore, a structure is formed wherein the liquid coolant discharge section of the pump is directly connected to the liquid cooled heat sink by means of a pipe, etc.
> [0010] Furthermore, an arrangement is adopted whereby the pump operates from a direct current power supply.
> [0011] Moreover, a structure is formed whereby the pump is secured to the liquid cooled heat sink across a vibration absorption member or the like.
> [0012]

Shin P [0008-0011]

[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin [0012]

[0013] In the present embodiment example, a structure is employed whereby the pump 5 is secured to the liquid cooled heat sink 4 across a vibration absorbing member 19. Thus, a structure is formed whereby the vibration of the pump 5 does not readily have a direct effect on the CPU or other electronic component. The pump 5 is connected to the

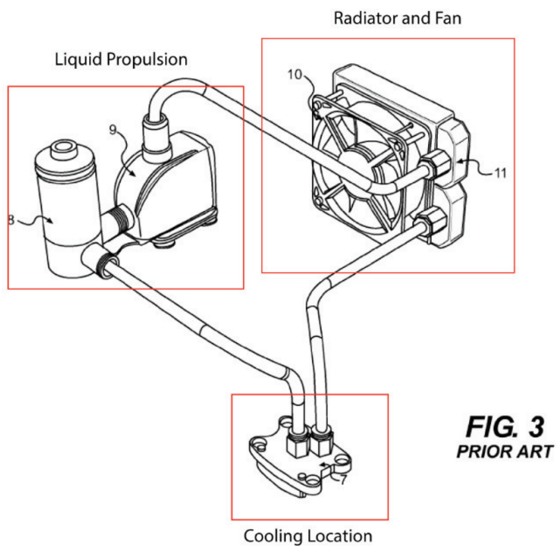
Shin [0013]

[0030] Furthermore, an integral component kit comprising this pump and liquid cooled heat sink can be installed instead of an air cooled heat sink with fan as frequently used in conventional personal computers and the like, making it possible to adopt a liquid cooling system into electronic devices without difficulty. If the power supply of the pump is compatible with the fan power supply for an air cooled heat sink with fan, the adoption of course becomes even easier.

Shin [0030]

286. To the extent this was not disclosed or taught by Shin, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on

thermal management of electronics. This is shown by the following figure, which was cited as prior art in the asserted patents:

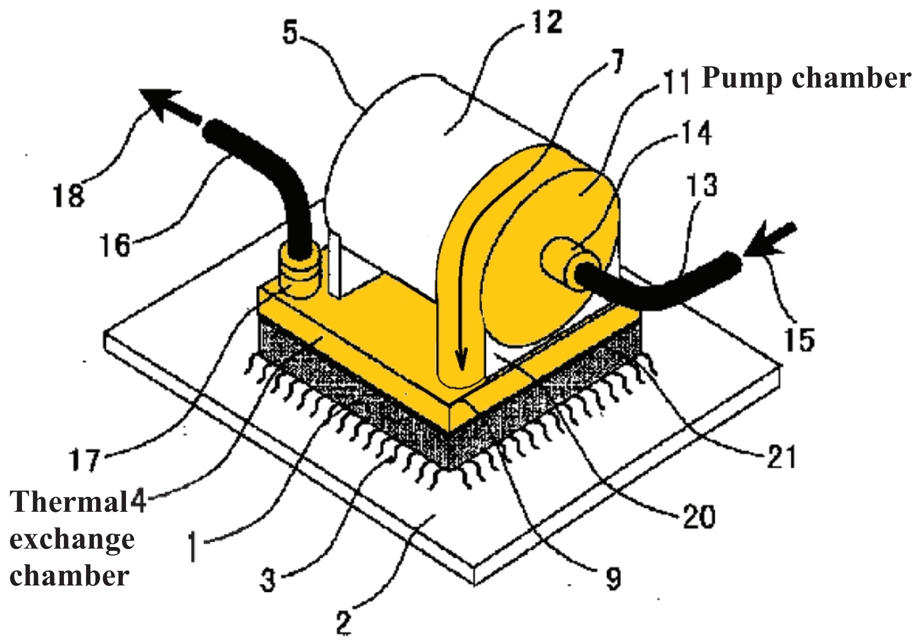


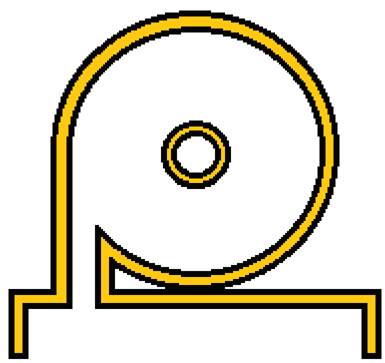
’196 Figure 3, prior art

287. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

1(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

288. Shin renders obvious a reservoir (denoted by golden color below) that is configured to circulate a cooling liquid therethrough, as I have already opined above. I adopt that prior analysis here.





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

289. To the extent that this limitation was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious in view of Duan for reasons I have already articulated in my discussion of Ground 1. This is because Duan discloses a reservoir. I adopt that prior analysis here. As I have already stated, a POSA would have been motivated to utilize a reservoir for circulating a cooling liquid because reservoirs are

efficient and simple means of routing fluid to a heated region and thus facilitate heat removal from that region.

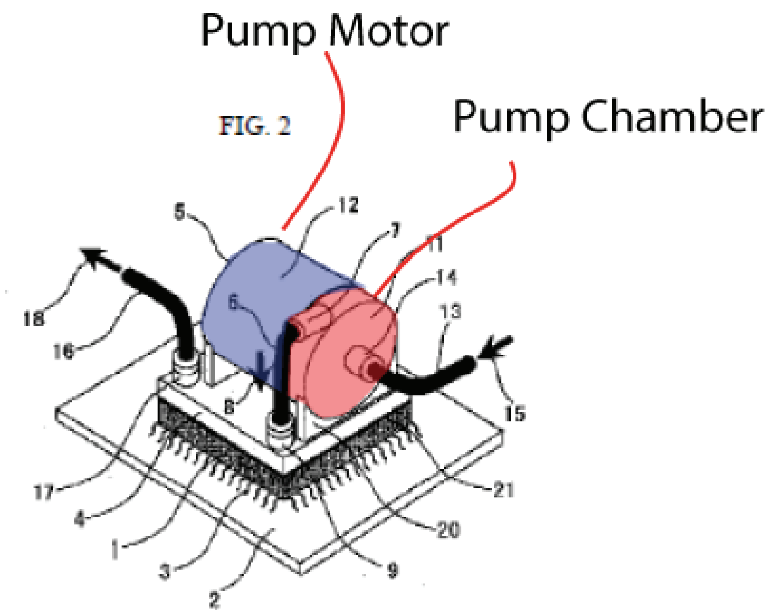
1(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being position on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes:

290. Shin discloses a pump chamber that houses an impeller and defined at least in part by an impeller cover and a double-sided chassis. The impeller is positioned on one side of the chassis and a stator of the pump is positioned on the opposite side of the chassis.

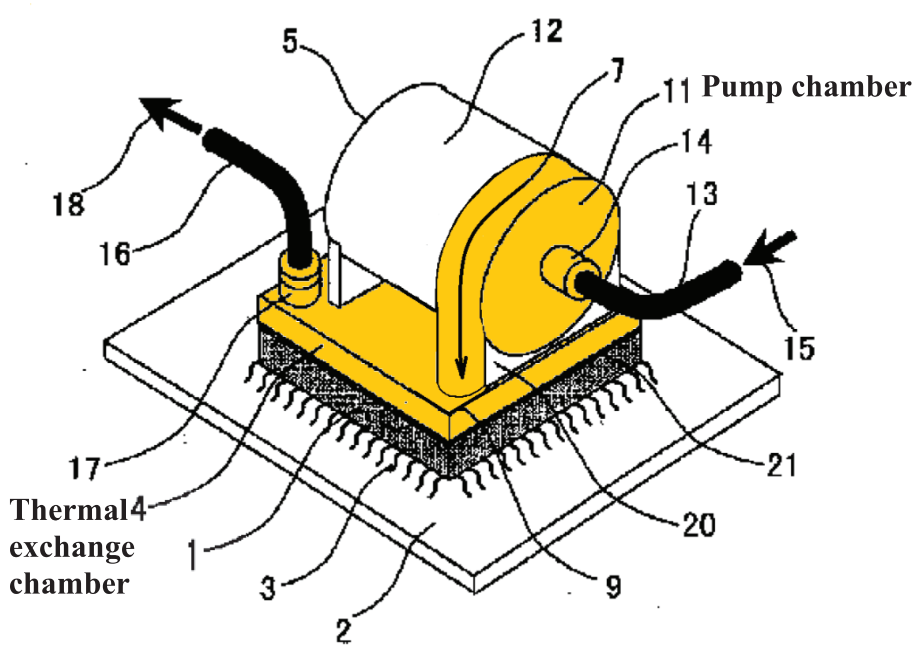
> [0018] The pump 5 comprises an impeller case 11 and motor 12. In the present embodiment example, the pump 5 illustrates an example of a centrifugal type pump which pressurizes liquid coolant by rotating an impeller arranged inside the impeller case 11, but a volumetric type pump

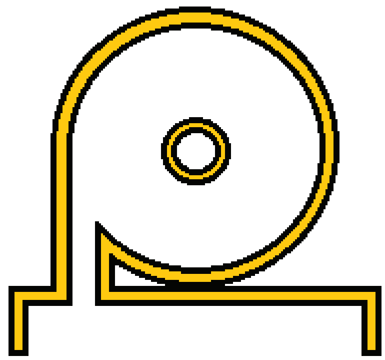
Shin [0018]

291. The impeller of Shin is contained within impeller case 11 while the stator is provided within motor 12. The claimed double-sided chassis is the interface between impeller case 11 and motor 12.



Shin, Figure 2
(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

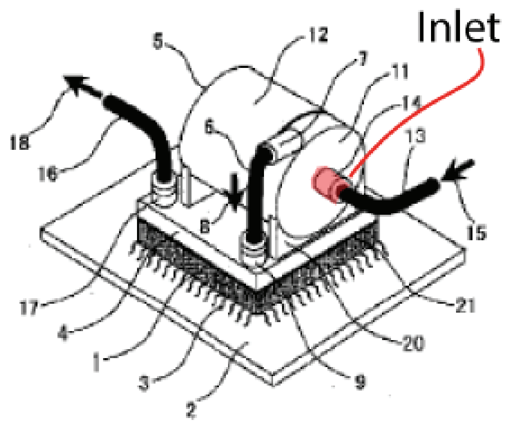
292. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious in view of the experience, education, and training of a POSA. Utilizing a pump wherein the stator and the impeller are separated by a double-sided chassis and the impeller is confined to a pump chamber is routine for a POSA working with pumps and thermal management of electronics. A POSA would have been motivated to use a pump chamber housing an impeller and defined by an impeller cover and a double-sided chassis with the impeller and stator positioned on opposite sides of the chassis. Such a design isolates the stator from the impeller and facilitates the routing of fluid to the heated region.

293. To the extent that this was not disclosed or taught by Shin with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

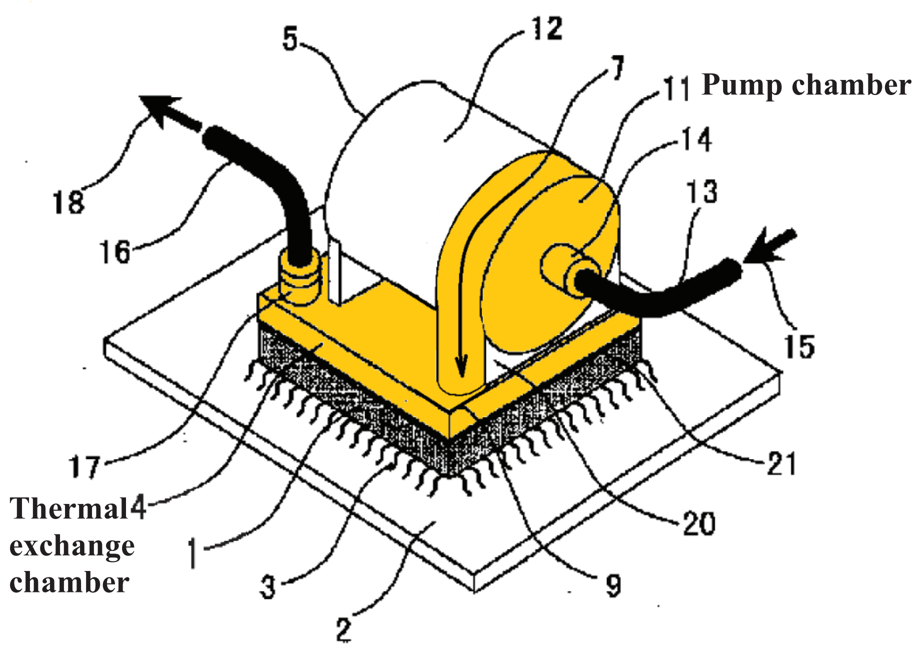
294. Shin discloses an inlet defined by the impeller cover positioned below a center of the impeller and configured to enable a liquid to flow into the center of the pump chamber.

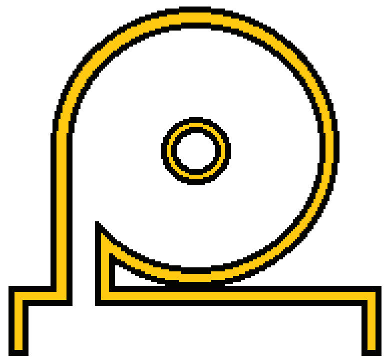
FIG. 2



Shin, Figure 2

(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

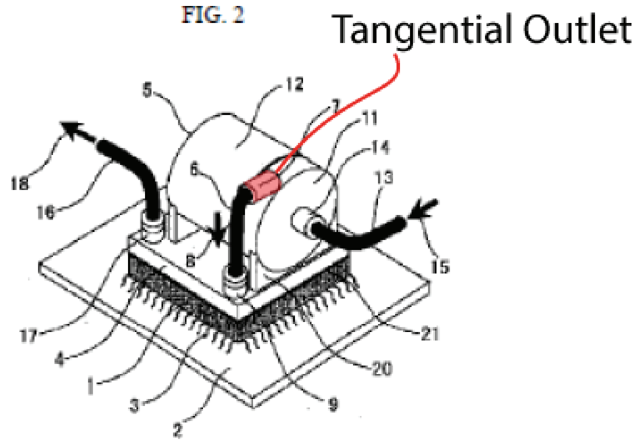
295. To the extent this was not disclosed or taught by Shin, it would have been obvious based on the experience, education, and training of a POSA. Inlets to pumps provided by an inlet in the center of a pump are extremely common and ubiquitous. I have worked with such pumps numerous times in my career and these would be routine for a POSA working with pumps or the thermal management of heat-generating components. A POSA would have been motivated to incorporate an impeller cover positioned below a center of the impeller and configured to enable a cooling fluid to flow into the center of the pump chamber. Such an arrangement is a simple and hydraulically efficient way to route fluid and reduce fluid connections and to improve heat transfer.

296. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller,

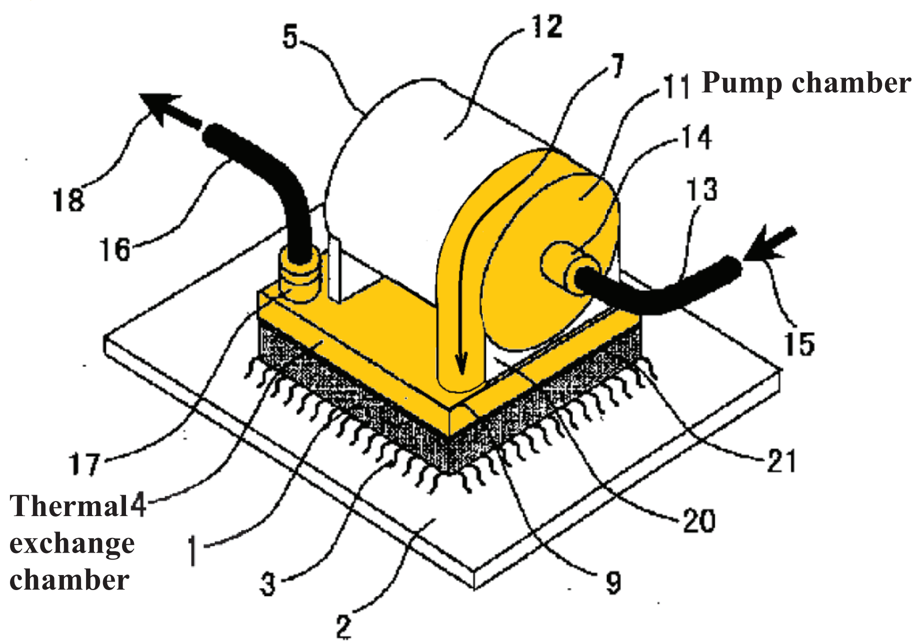
297. Shin discloses an outlet defined by the impeller cover and positioned tangentially to the circumference of the impeller, as shown here.

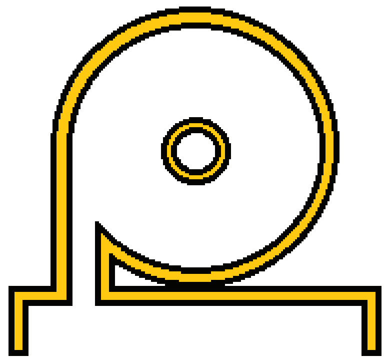
FIG. 2



Shin, Figure 2

(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below – the tangential outlet is still labeled as 7)





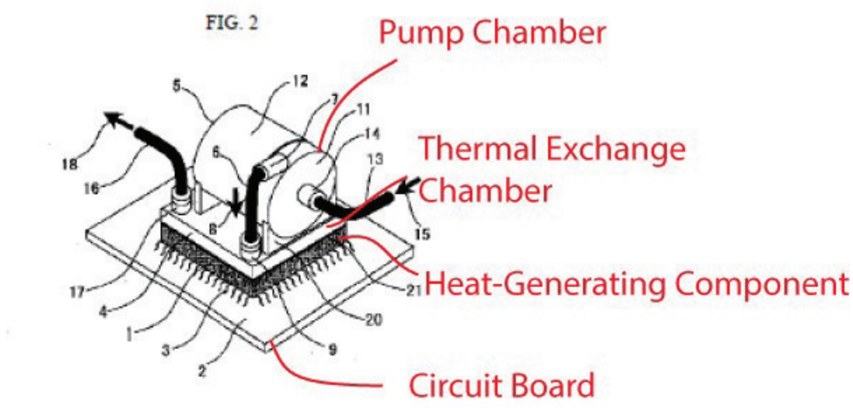
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

298. To the extent this limitation is not taught by Shin, it would have been obvious based on the experience, education, and training of a POSA. Pumps commonly have outlets that are positioned tangentially to the circumference of the impeller, as claimed. I have personally worked with numerous pumps that are so designed. A POSA would have been motivated to position an outlet tangential to the circumference of the impeller because this reduces hydraulic resistance and improves the pump performance.

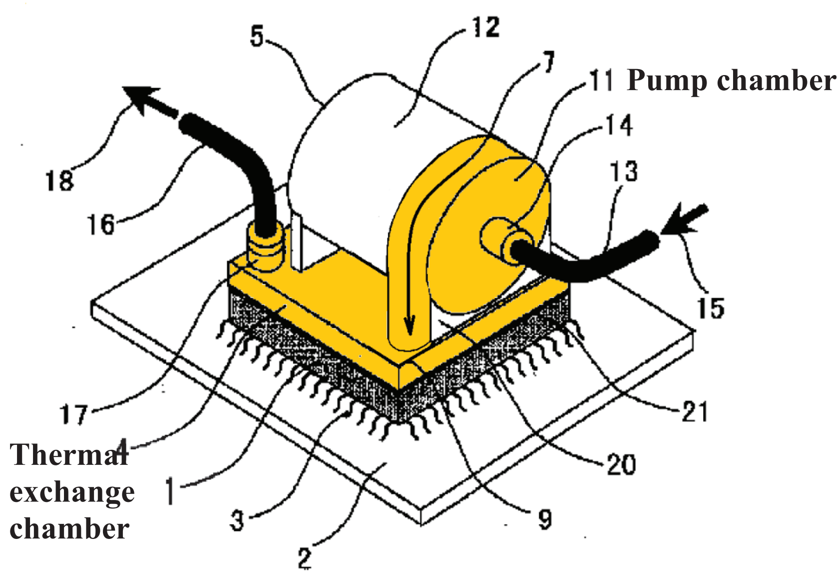
299. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

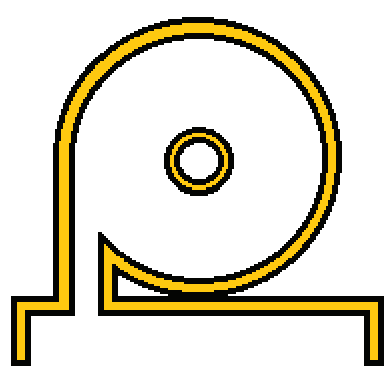
1(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

300. Shin discloses a thermal exchange chamber (20) that is disposed between a pump chamber and a heat-generating component when the system is installed on a heat-generating component, as shown here:



Shin, Figure 2
(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

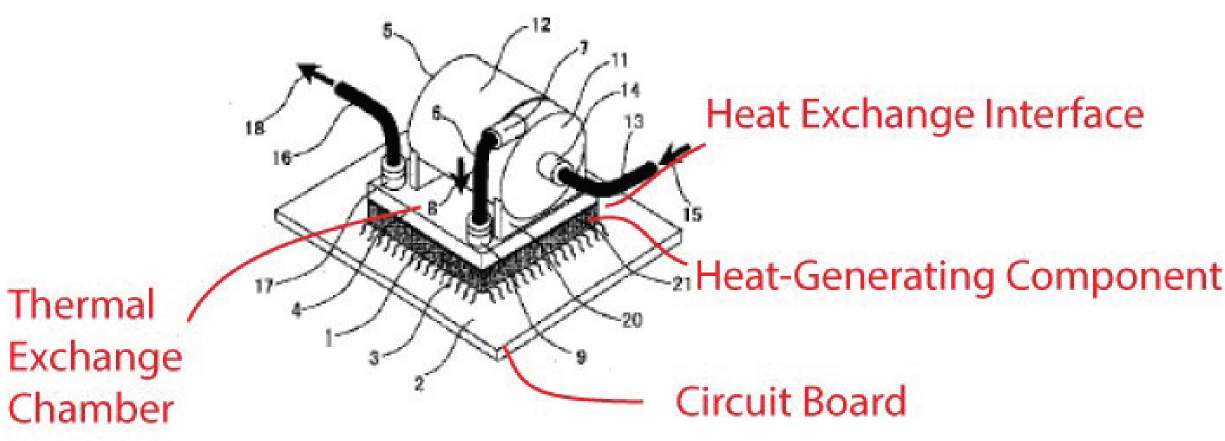
301. To the extent this was not disclosed or taught by Shin, it would have been obvious based on the experience, education, and training of a POSA. Implementing a thermal exchange chamber between a pump chamber and a heat-generating component is commonly performed by a POSA working in thermal management of electronics. The motor region of a liquid pump houses the electric and largely stationary components of the electric motor while the pump chamber houses the rotating impeller that provides the locomotion to the fluid. A POSA would have been motivated to incorporate a thermal exchange chamber disposed between the pump chamber and the heat-generating component because the close proximity of the thermal exchange chamber and the heat-generating component would reduce thermal resistance and lower temperatures.

302. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of channels that direct the flow of the cooling liquid within the thermal exchange chamber;

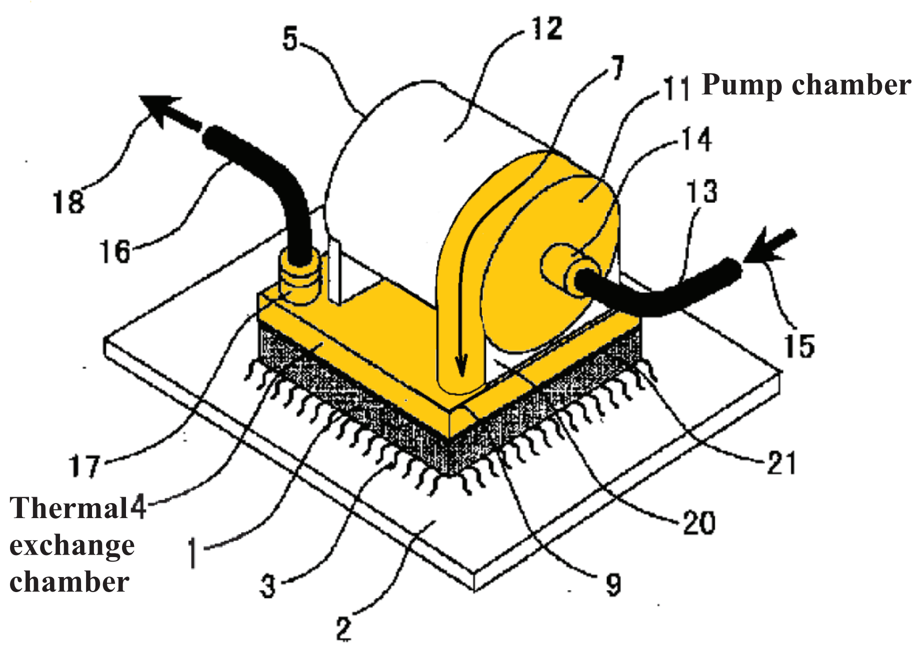
303. Shin discloses a heat-exchanging interface that forms a boundary wall of the thermal exchange chamber as claimed.

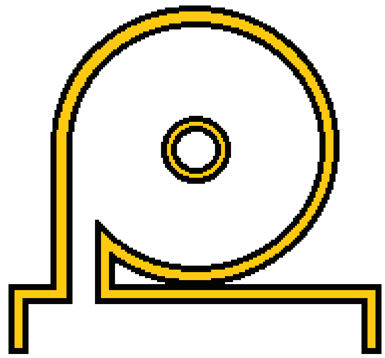
FIG. 2



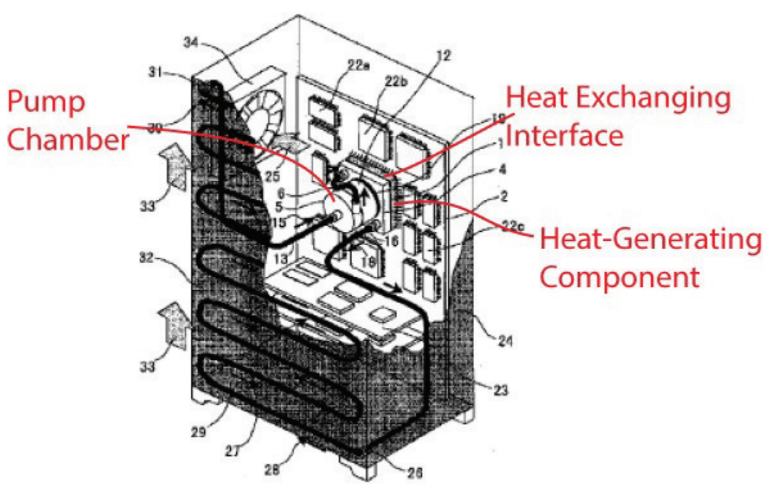
Shin, Figure 2

(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)



Shin, Figure 3

304. The heat-exchanging interface of Shin is placed in thermal contact with the heat-generating components, as discussed here.

[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin, [0012]

[Means for solving the problem] To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink.

Shin, [0007]

305. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious based on the experience, education, and training of a POSA. When cooling computer systems, the cooling device is to be placed in intimate thermal contact with the heat-generating component. In fact, I teach both undergraduate and graduate students the importance of good thermal contact for these devices. In addition, the use of fins which serve as flow channels, or the implementation of other types of flow channels is routine for the design of thermal-exchange chambers. I have personally designed multiple thermal exchange chambers with channels that facilitate the heat transfer from heat-

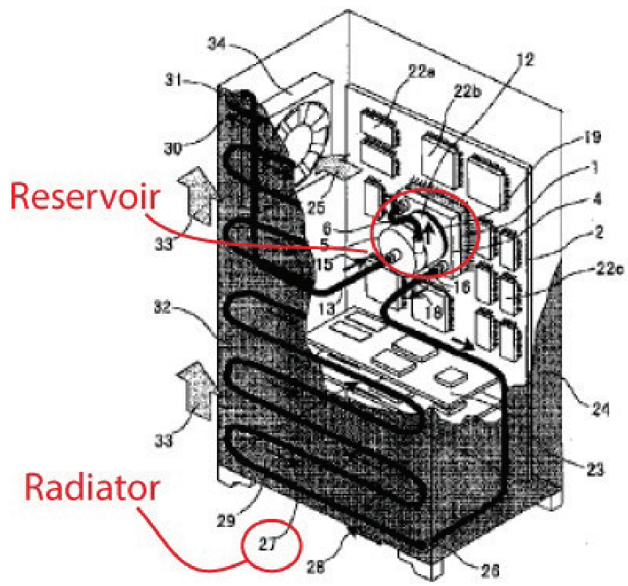
generating components to a coolant in a thermal exchange chamber. A POSA would have been motivated to use a heat-exchanging interface that is a boundary wall of the thermal exchange chamber and in thermal contact with a heat-generating component and with an inner surface that has a plurality of channels to direct the flow. The close proximity of the heat-exchange interface to the thermal exchange chamber and to the heat-generating component reduces the thermal resistance and lowers the temperature. In addition, use of channels increases the convective heat transfer and also reduces temperatures.

306. To the extent that this was not disclosed or taught by Shin ,with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

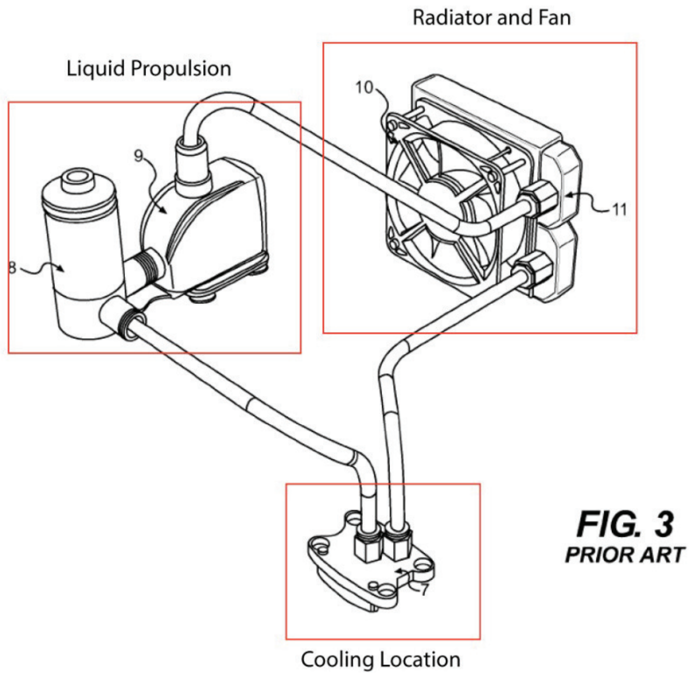
307. Shin discloses the claimed heat radiator adapted to pass cooling liquid therethrough with the radiator being fluidly coupled to the reservoir via fluid conduits.

308. Shin discloses a heat radiator that is adapted to pass cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir by fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid. The radiator and reservoir of Shin are fluidly coupled by tubing (26).



Shin Figure 4

309. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious based on the experience, education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems. This is supported by the following image, which was provided as prior art in the asserted patents. A POSA would have been motivated to use a radiator adapted to pass cooling liquid therethrough with the radiator coupled to the reservoir. Such an arrangement allows the heat from the heat-generating component to be removed from the vicinity of the heat-generating location and transferred to the ambient environment in an efficient manner.

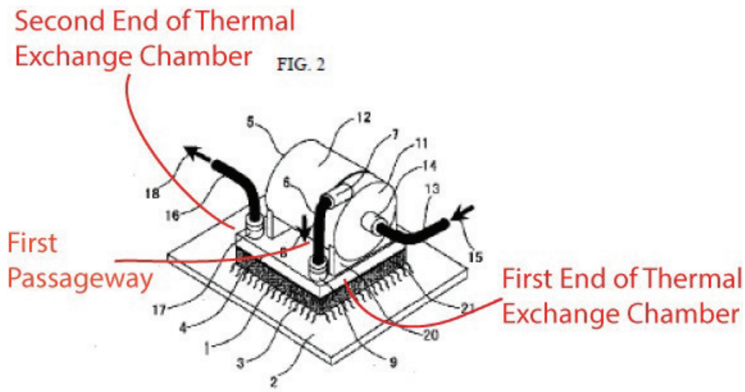


’196 patent, Figure 3

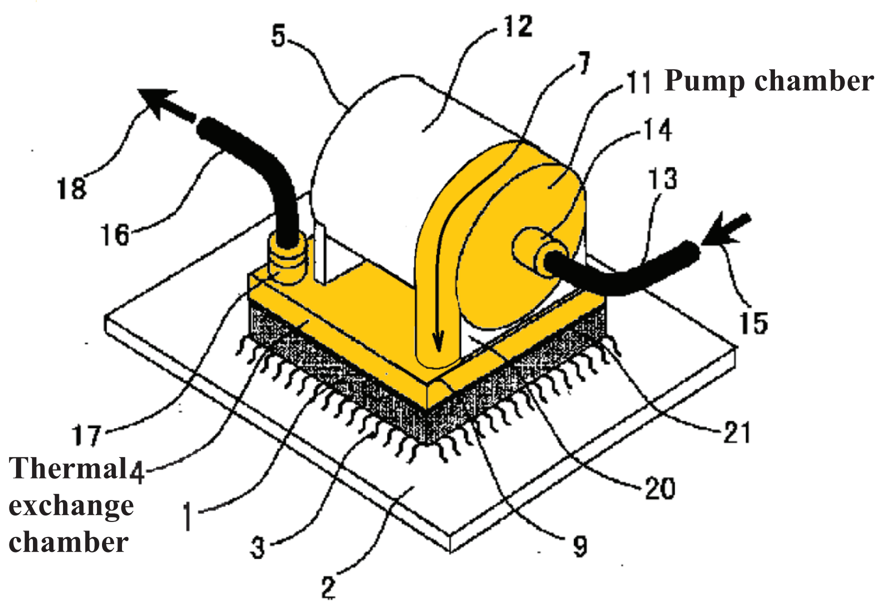
310. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

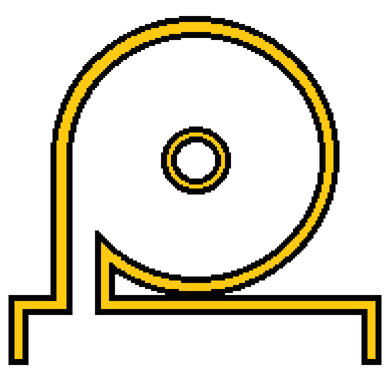
1(h) a first passage fluidly coupling the pump chamber and the thermal exchange chamber, wherein the first passage is configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber.

311. Shin discloses a first passage that fluidly couples the pump chamber to the thermal exchange chamber. The first passage is configured to direct cooling liquid from the outlet of the pump chamber into the thermal exchange chamber, between a first end and second end of the thermal exchange chamber.



Shin, Figure 2
(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





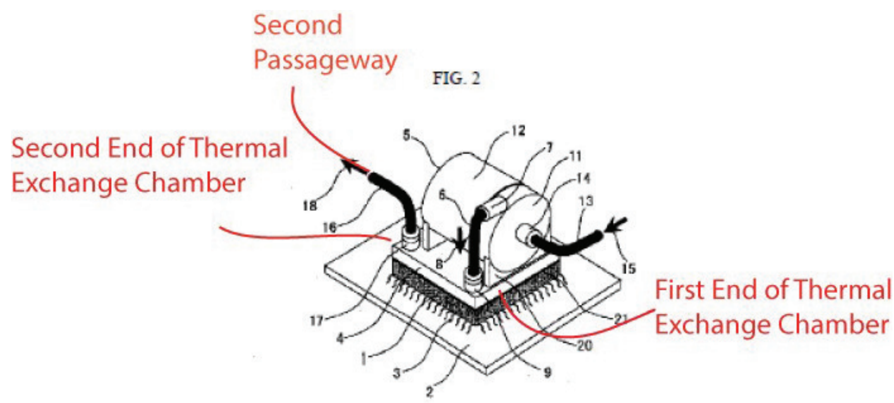
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

312. To the extent this limitation was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on her experience, education, and training. Liquid pumps are designed with outlets through which liquid flows. In electronics cooling devices, the cooling liquid is propelled toward the heat-generating device to a thermal exchange chamber where heat transfer occurs. I have worked with and taught students the operation, design, and analysis of such systems for years. A POSA would have been motivated to utilize a passage to fluidly couple the pump chamber and the thermal exchange chamber. This allows the cooling liquid to pass from the pump chamber to the thermal exchange chamber. Positioning the passage such that the liquid flows from the pump chamber to and thermal exchange chamber between the first and second ends of the thermal exchange chamber allows the cooling fluid to more directly impact the heat transfer region and facilities a more uniform temperature.

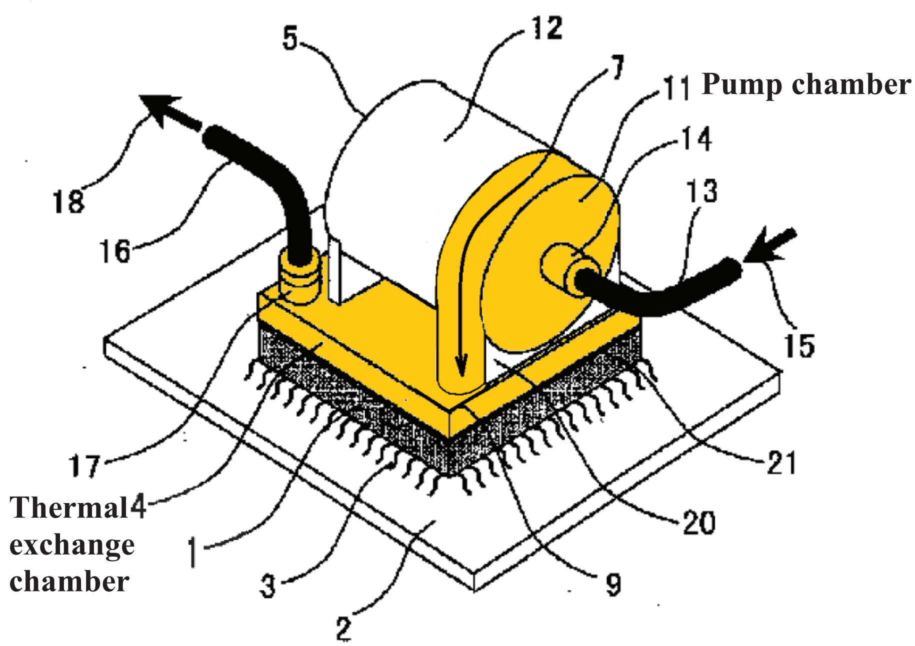
313. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

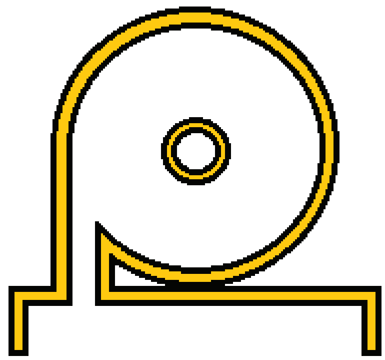
Claim 2: The cooling system of claim 1, wherein the thermal exchange chamber includes at least one second passage configured to direct the cooling liquid out of the thermal exchange chamber, the at least one second passage is positioned at either a first end or a second end of the thermal exchange chamber.

314. Shin discloses or teaches this limitation, as shown below. Second passage (18) carries liquid from the thermal exchange chamber; the direction of flow is indicated by the black arrows in the figure.



Shin, Figure 2
(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

315. To the extent this claim was not disclosed or taught by Shin, it would have been obvious in view of the experience, education, and training of a POSA. In fact, the thermal exchange chamber is required to have at least a passageway that carries coolant from the chamber. The positioning of the second passageway at either a first end or a second end is a matter of routine design choice. I have personally designed similar systems wherein the passageway that directs fluid out of a thermal exchange chamber is positioned at an end of the chamber. A POSA would have been motivated to use a thermal exchange chamber that includes a second passage configured to direct cooling liquid out of the thermal exchange chamber so that the fluid can circulate between the two chambers and draw heat away from the heat-generating component and distribute the heat to the ambient environment.

316. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 10 Preamble A liquid cooling system for cooling a heat-generating component of a computer, comprising;

317. As discussed in connection with claim 1, Shin discloses this preamble. I adopt that analysis here.

318. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

319. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here. A POSA would have been motivated to use four legs to secure the thermal exchange interface to the heat-generating component because the legs provide a uniform contact at the interface and thereby reduces thermal resistance.

10(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including,

320. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

321. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

322. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being positioned on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes,

323. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

324. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

325. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

326. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

327. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

328. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller;

329. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

330. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

331. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

332. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

333. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

334. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of parallel channels that are configured to direct the flow of the cooling liquid within the thermal exchange chamber;

335. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

336. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

337. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

338. As discussed in connection with claim 1, Shin discloses or teaches this limitation. I adopt that analysis here.

339. To the extent this was not disclosed or taught by Shin alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

340. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(h) a set of four mounting legs configured to secure the heat-exchanging interface to a heat-generating component of a computer.

341. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious to a POSA based on her experience, education, and training. In fact, the use of mounting legs to secure heat-exchanging interface to a heat-generating component is routine. This is made clear by the asserted prior art referenced in the '196 patent, as shown below.

342. Retaining frame 3 has four legs which are matched with four legs of brace 6.

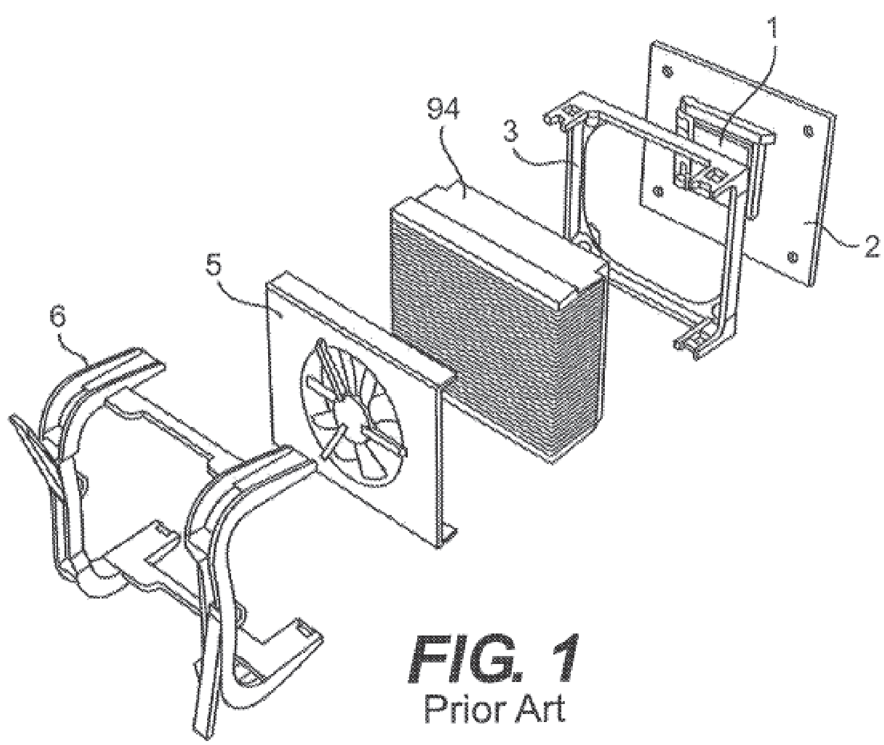


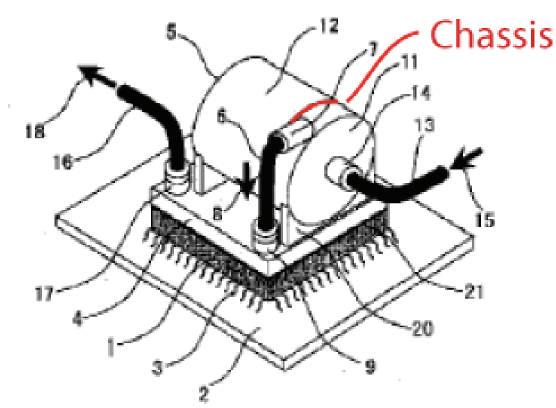
FIG. 1
Prior Art

343. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 13: The liquid cooling system of claim 10, wherein the double-sided chassis defines a recess configured to house the stator.

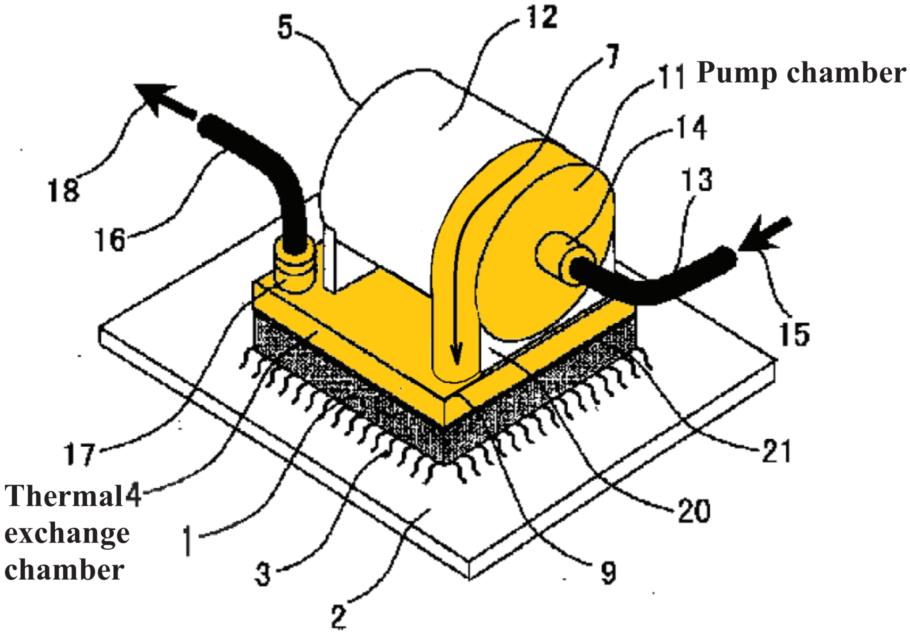
344. Shin discloses a chassis, positioned as shown in the following image. The chassis is double-sided and it separates the motor portion from the impeller portion of the pump 5. The motor inherently has a recess to house the motor components, including the stator and the chassis would help define said recess.

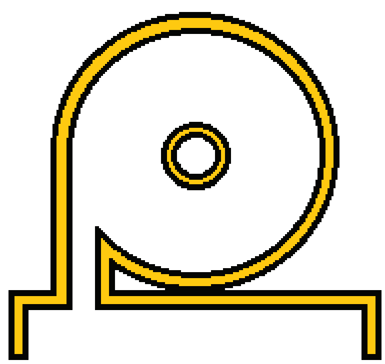
FIG. 2



Shin, Figure 2

(with the pump chamber and the thermal exchange chamber integrated into a one-receptacle structure as shown below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

345. To the extent this claim was not disclosed or taught by Shin alone, it would have been obvious based on the experience, education, and training of a POSA. In fact, I have worked with numerous pumps like that described in Shin with a double-sided chassis that defines a recess to house the stator. A POSA would have been motivated to use a double sided chassis with a recess to house the stator because this arrangement effectively

isolates the stator from the impeller and helps the pump efficiently direct fluid to the heated region where is removes heat and transfers the heat to the ambient environment.

346. To the extent that this was not disclosed or taught by Shin with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

C. Ground 3 – Ryu in View of Duan

347. It is my opinion that Ryu in view of Duan renders claims 1, 2, and 13 of the ’196 patent invalid.

Claim 1 (preamble) A liquid cooling system for cooling a heat-generating component of a computer, comprising

348. While I do not understand that the preamble to this claim is limiting, if it is limiting then Ryu discloses this preamble. First, Ryu is entitled “WATER COOLED COOLING DEVICE FOR THE CENTRAL PROCESSING UNIT OF A COMPUTER WITH AN IMPELLER”

349. Ryu further discloses the following:

Abstract

The present invention relates to a water-cooled cooling device for a computer's central processing unit having an impeller for circulating the water-cooled by a radiator inside a water jacket provided on the upper surface of the central processing unit of the computer to cool the heat generated from the central processing unit, and

Comprises a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit;

An impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and

A drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

Ryu, Abstract

Technical problems to be solved by the invention

The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for cooling the heat generated from the central processing unit using the circulating cooling water.

Ryu, Page 3

Comprises a pump driving unit having a first inlet, discharging unit, and a first outlet; and a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water, or

A pump driving unit having a first inlet, discharging unit, and a first outlet; a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water; an inlet pipe exposed and formed between the water jacket and the pump driving unit to connect the first inlet and the second inlet; and a discharge pipe exposed and formed between the water jacket and the pump driving unit to connect the discharging unit and the second outlet, and in this case, it is preferable that the coupling clip mounts the water jacket to the central processing unit.

The water jacket is made of aluminum material, and specifically, a plurality of porous aluminum plates having a plurality of holes formed in a shape of a honeycomb is stacked and then joined by a brazing technique to form multiple water passages on the inside of the water jacket.

Ryu, Page 4

In order to achieve the said object, a water-cooled cooling device for computer central processing units having an impeller according to the present invention is a water-cooled cooling device for computer central processing units capable of cooling the central processing unit of a computer by receiving the cooled water and circulating therein, and is characterized by comprising a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit; an impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and a drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

In addition, it further comprises a coupling clip for mounting the combination of the circulation unit, impeller, and drive motor to the central processing unit,

Ryu, Page 4

In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit.

Ryu, Page 4

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, Page 5

As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

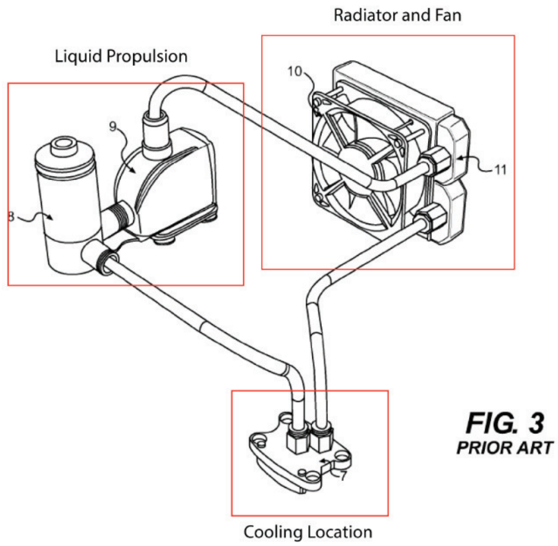
A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

Ryu, Page 6

In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.[1]

Ryu, Page 7

350. To the extent this was not disclosed or taught by Ryu, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics. This is shown by the following figure, which was cited as prior art in the asserted patents: A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.



’196 Figure 3, prior art

351. To the extent that this was not disclosed or taught by Ryu with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

352. Ryu in view of Duan renders this limitation obvious. This is because Duan discloses a reservoir for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here. A POSA would have been motivated to utilize a reservoir for circulating a cooling liquid because reservoirs are efficient and simple means of routing fluid to a heated region and thus facilitate heat removal from that region.

In order to achieve the said object, a water-cooled cooling device for computer central processing units having an impeller according to the present invention is a water-cooled cooling device for computer central processing units capable of cooling the central processing unit of a computer by receiving the cooled water and circulating therein, and is characterized by comprising a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit; an impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and a drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

In addition, it further comprises a coupling clip for mounting the combination of the circulation unit, impeller, and drive motor to the central processing unit,

Ryu, page 4

In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit.

Ryu, Page 4

Comprises a pump driving unit having a first inlet, discharging unit, and a first outlet; and a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water, or

A pump driving unit having a first inlet, discharging unit, and a first outlet; a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water; an inlet pipe exposed and formed between the water jacket and the pump driving unit to connect the first inlet and the second inlet; and a discharge pipe exposed and formed between the water jacket and the pump driving unit to connect the discharging unit and the second outlet, and in this case, it is preferable that the coupling clip mounts the water jacket to the central processing unit.

Ryu, Page 4

Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

Ryu, Page 5

Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

Ryu, Page 5

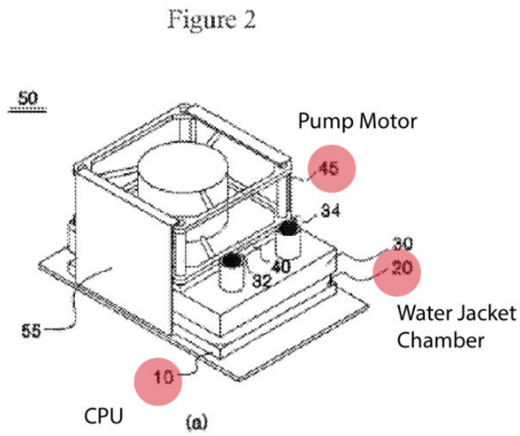
As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

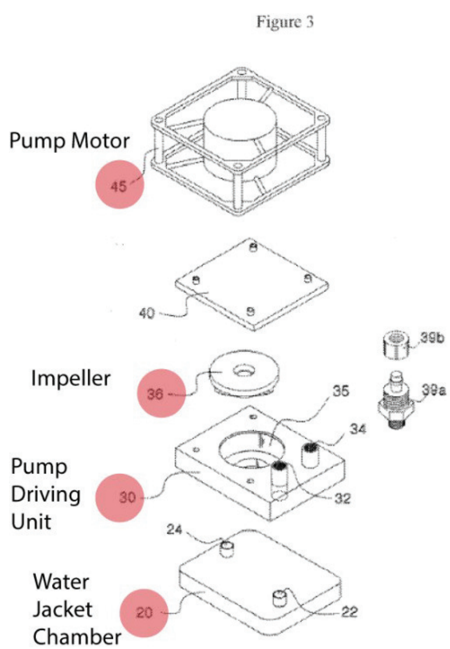
Ryu, Page 6

In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.[1]

Ryu, Page 7



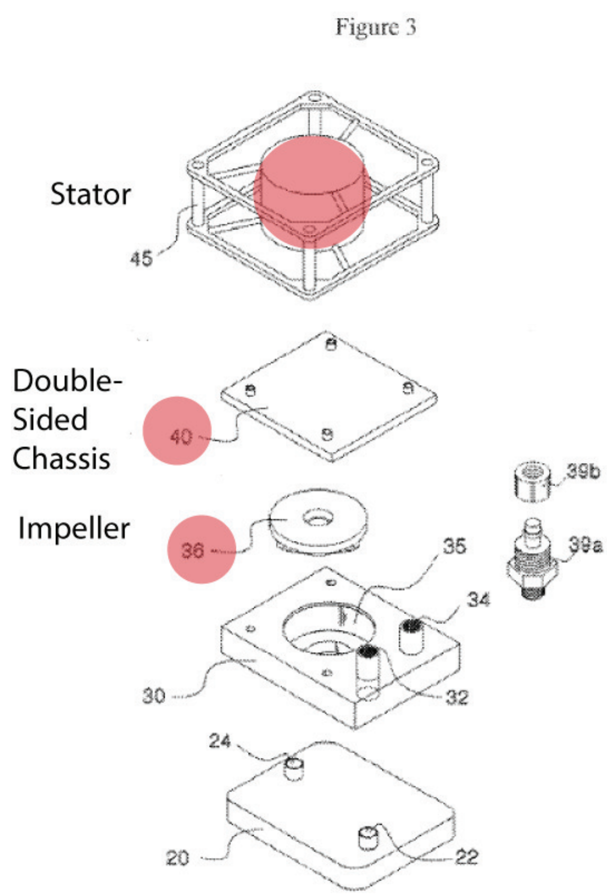
Ryu Figure 2



Ryu Figure 3

1(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being position on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes:

353. Ryu discloses the claimed pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being positioned on one side of the chassis and a stator of the pump positioned on an opposite side of the chassis.



Ryu, Figure 3

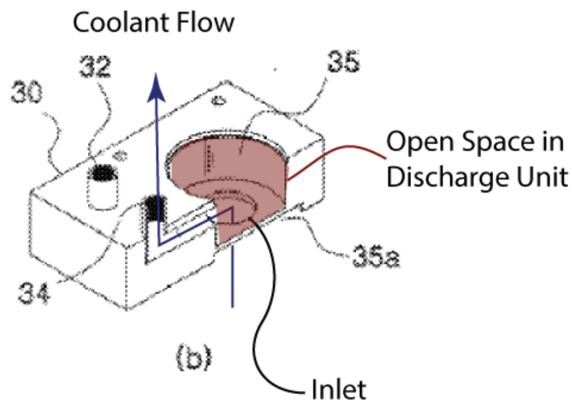
354. To the extent this limitation was not disclosed or taught by Shin, it would have been obvious in view of the experience, education, and training of a POSA. Utilizing a pump wherein the stator and the impeller are separated by a double-sided chassis and the impeller is confined to a pump chamber is routine for a POSA working with pumps and thermal management of electronics. A POSA would have been motivated to use a pump chamber housing an impeller and defined by an impeller cover and a double-sided chassis with the impeller and stator positioned on opposite sides of the chassis. Such a design isolates the stator from the impeller and facilitates the routing of fluid to the heated region.

355. To the extent that this was not disclosed or taught by Shin with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

356. Ryu discloses or teaches this limitation. It has an inlet defined by the impeller cover positioned below a center of the impeller and configured to enable cooling liquid to flow into the center of the pump chamber.

Figure 4



From Ryu, Figure 4

The water for which the temperature has risen while passing through the water jacket (20) is discharged to the discharging unit (35) of the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the discharging unit (34) of the pump driving unit by the operation of the impeller (36) to be introduced into the radiator (60) through the inlet tube (68).

[PAGE * MERGEFORMAT]

COOLIT00

Laid-open Patent 2003 - 0031027

The pump driving unit (30) according to the present invention is mounted to the upper portion of the water jacket (20) to introduce the cooling water discharged from the radiator (60) into the water jacket, and to pump and discharge the water that has passed through the water jacket to the radiator (60). The pump driving unit (30) comprises an inlet (32) connected to the outlet tube (66) to receive the cooling water discharged from the radiator (60), an outlet (34) for discharging the water that has passed through the water jacket (20) to the inlet tube (68), and a discharging unit (35) formed in a groove shape so that the water discharged from the water jacket can be gathered and having an impeller (36) mounted on the inside. The discharging unit (35) is formed in a groove shape to be caved in so that a predetermined amount of water that has been pumped from the water jacket by the operation of the impeller (36) can be gathered, and an outlet (34) for discharging the gathered water by the operation of the impeller (36) is formed on one side. In addition, a space (35a) is formed on the lower portion of the discharging unit so that the outlet (24) of the water jacket (20) can be exposed and opened, and the water from the water jacket is discharged to the discharging unit through said space. Therefore, the water that has passed through the water jacket (20) is pumped up to the discharging unit (35) by the operation of the impeller (36) and then discharged to the outlet (34) of the pump driving unit (30) to be introduced into the radiator (60) through the inlet tube (68).

Ryu, pages 7-8

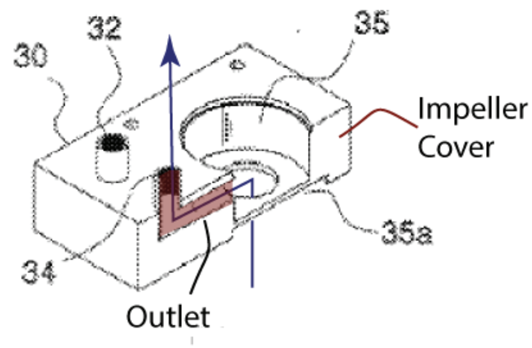
357. To the extent this was not disclosed or taught by Ryu, it would have been obvious based on the experience, education, and training of a POSA. Inlets to pumps provided by an inlet in the center of a pump are extremely common and ubiquitous. I have worked with such pumps numerous times in my career and these would be routine for a POSA working with pumps or the thermal management of heat-generating components. A POSA would have been motivated to incorporate an impeller cover positioned below a center of the impeller and configured to enable a cooling fluid to flow into the center of the pump chamber. Such an arrangement is a simple and hydraulically efficient way to route fluid and reduce fluid connections and to improve heat transfer.

358. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller,

359. Ryu discloses or teaches this limitation. It teaches an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller, as shown below.

Figure 4



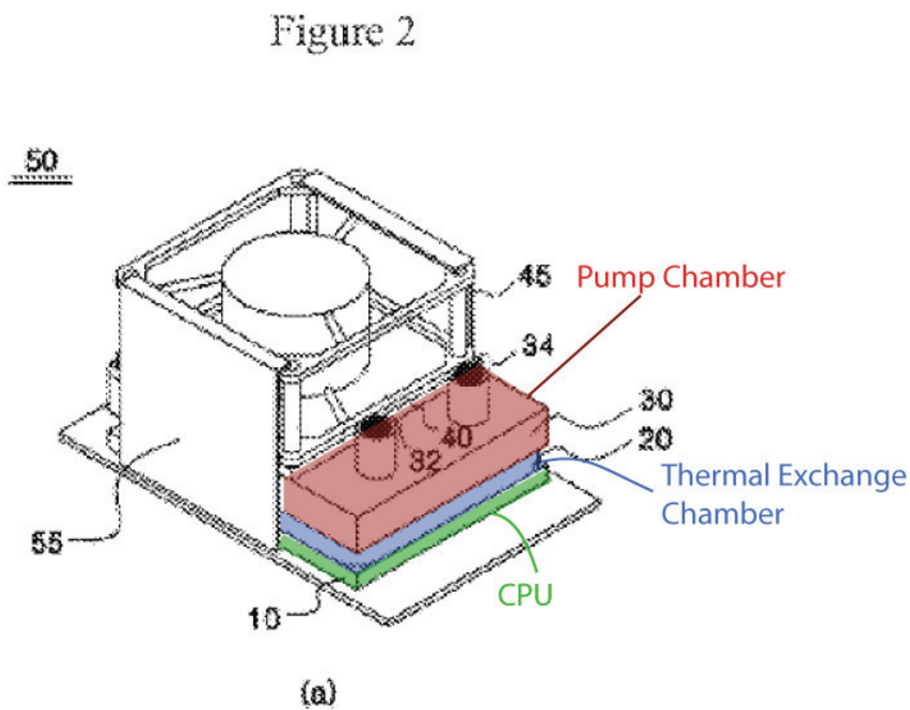
From Ryu Figure 4

360. To the extent this limitation is not taught by Shin, it would have been obvious based on the experience, education, and training of a POSA. Pumps commonly have outlets that are positioned tangentially to the circumference of the impeller, as claimed. I have personally worked with numerous pumps that are so designed. A POSA would have been motivated to position an outlet tangential to the circumference of the impeller because this reduces hydraulic resistance and improves the pump performance.

361. To the extent that this was not disclosed or taught by Shin, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

362. Ryu discloses or teaches this limitation. It teaches a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component.



Ryu, Figure 2a

363. To the extent this was not disclosed or taught by Ryu, it would have been obvious based on the experience, education, and training of a POSA. Implementing a thermal exchange chamber between a pump chamber and a heat-generating component is commonly performed by a POSA working in thermal management of electronics. The motor region of a liquid pump houses the electric and largely stationary components of the electric motor while the pump chamber houses the rotating impeller that provides the locomotion to the fluid. A POSA would have been motivated to incorporate a thermal exchange chamber disposed between the pump chamber and the heat-generating component

because the close proximity of the thermal exchange chamber and the heat-generating component would reduce thermal resistance and lower temperatures.

364. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of channels that direct the flow of the cooling liquid within the thermal exchange chamber;

365. Ryu discloses or teaches this limitation. It teaches a heat-exchanging interface that forms a boundary wall of the thermal exchange chamber, the heat-exchanging interface is configured to be placed in thermal contact with a surface of the heat generating component and with an inner surface that defines a plurality of channels that direct the flow of cooling liquid within the thermal exchange chamber.

366. Ryu discusses the thermal contact between the heat-exchanging surface and the heat-generating component, for example:

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a ‘C’ shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

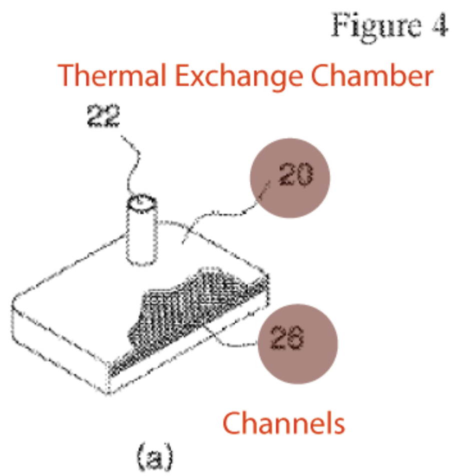
Ryu, page 5

The water jacket (20) according to the present invention is mounted to the upper surface of the central processing unit (10) to cool the central processing unit (10) by receiving the cooling water discharged after being cooled in the radiator (60) through the pump driving unit (30) and having it pass through on the inside, and discharge the water, which has been heated by the heat transmitted from the central processing unit while passing through the inside, again to the radiator (60) through the pump driving unit (30). The water jacket (20) is

Ryu, Page 7

In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.

Ryu, page 7



Ryu, Figure 4

367. To the extent this limitation was not disclosed or taught by Ryu, it would have been obvious based on the experience, education, and training of a POSA. When cooling computer systems, the cooling device is to be placed in intimate thermal contact with the heat-generating component. In fact, I teach both undergraduate and graduate students the importance of good thermal contact for these devices. In addition, the use of fins which serve as flow channels, or the implementation of other types of flow channels is routine for the design of thermal-exchange chambers. I have personally designed multiple thermal exchange chambers with channels that facilitate the heat transfer from heat-generating components to a coolant in a thermal exchange chamber. A POSA would have been motivated to use a heat-exchanging interface that is a boundary wall of the thermal exchange chamber and in thermal contact with a heat-generating component and with an inner surface that has a plurality of channels to direct the flow. The close proximity of the heat-exchange interface to the thermal exchange chamber and to the heat-generating

component reduces the thermal resistance and lowers the temperature. In addition, use of channels increases the convective heat transfer and also reduces temperatures.

368. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

369. Ryu discloses or teaches this limitation. It has a radiator that is adapted to pass cooling liquid therethrough. The heat radiator of Ryu is fluidly coupled to the reservoir via fluid conduits, the heat radiator is configured to dissipate heat from the cooling fluid.

Also, it may further comprise a radiator for receiving the water that has passed through the circulation unit, circulating it inside, cooling it, and then discharging the cooled water, and having a third inlet for receiving the water discharged through the first outlet, a plurality of water passages formed on the inside to distribute and circulate the introduced water, and a third outlet for discharging the water that has passed through the water passage; an inlet tube having one end connected to the first outlet and one end connected to the third inlet to introduce the water discharged through the first outlet to the third inlet; and an outlet tube having one end connected to the third outlet and one end connected to the first inlet to introduce the cooled water discharged through the third outlet to the first inlet, and

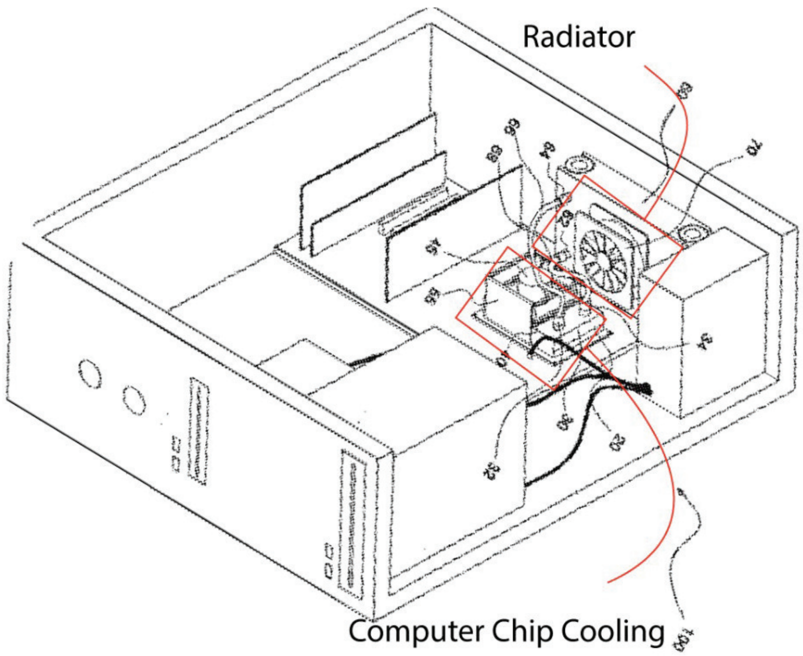
Ryu, page 5

Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

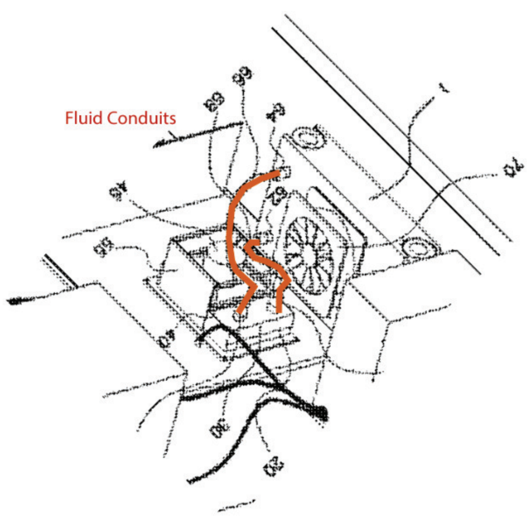
Ryu, page 5

The radiator (60) performs cooling by the operation of the cooling fan (70) while circulating the water for which the temperature has risen while passing through the water jacket (20). In this case, the cooling fan (70) may be provided at the front side of the radiator to circulate the internal air of the computer desktop (100), or it may be provided at the rear side of the radiator and a plurality of holes may be formed on the back surface of the computer desktop to have the cooling fan circulate the air from the outside, thereby enhancing the cooling efficiency of the radiator. The location of the cooling fan (70) may be freely changed according to the situation of the system.

Ryu, page 6



Ryu, Figure 1



Ryu, Figure 1

370. To the extent this was not disclosed or taught based on Ryu alone, it would have been obvious based on the experience, education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems. This is supported by the following image, which was provided as prior art in the asserted patents. A POSA would have been motivated to use a radiator adapted to pass cooling liquid therethrough with the radiator coupled to the reservoir. Such an arrangement allows the heat from the heat-generating component to be removed from the vicinity of the heat-generating location and transferred to the ambient environment in an efficient manner.

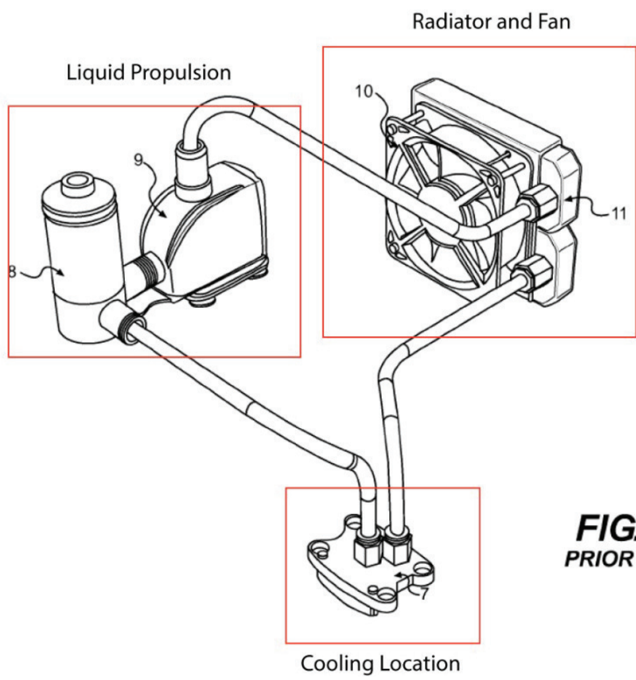


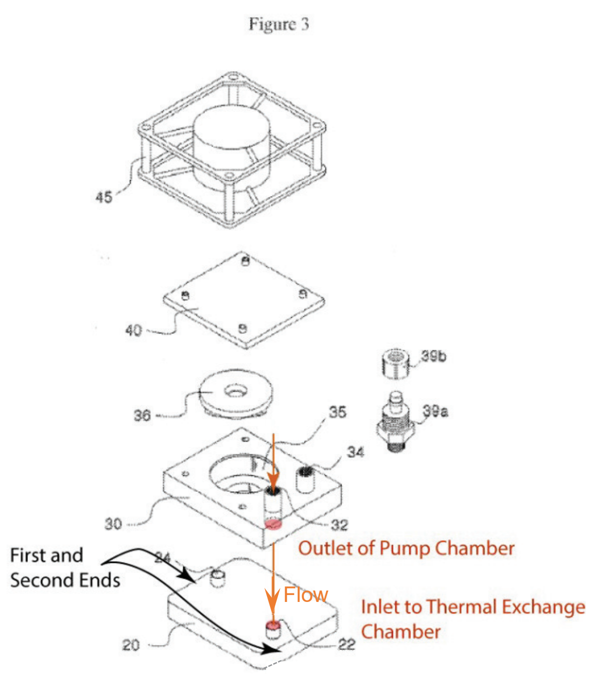
FIG. 3
PRIOR ART

’196 patent, Figure 3

371. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(h) a first passage fluidly coupling the pump chamber and the thermal exchange chamber, wherein the first passage is configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber.

372. Ryu discloses a fluid passage that couples the pump chamber with the thermal exchange chamber. The passage is configured to direct cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber.



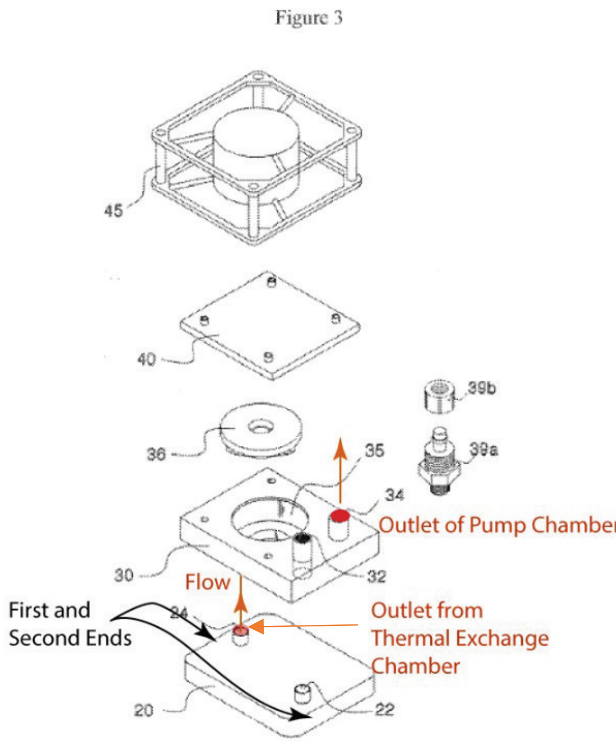
Ryu, Figure 3

373. To the extent this limitation was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on her experience, education, and training. Liquid pumps are designed with outlets through which liquid flows. In electronics cooling devices, the cooling liquid is propelled toward the heat-generating device to a thermal exchange chamber where heat transfer occurs. I have worked with and taught students the operation, design, and analysis of such systems for years. A POSA would have been motivated to utilize a passage to fluidly couple the pump chamber and the thermal exchange chamber. This allows the cooling liquid to pass from the pump chamber to the thermal exchange chamber. Positioning the passage between the first and second ends of the thermal exchange chamber allows the cooling fluid to more directly impact the heat transfer region and facilities a more uniform temperature.

374. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 2: The cooling system of claim 1, wherein the thermal exchange chamber includes at least one second passage configured to direct the cooling liquid out of the thermal exchange chamber, the at least one second passage is positioned at either a first end or a second end of the thermal exchange chamber.

375. Ryu discloses a fluid passage that couples the pump chamber with the thermal exchange chamber. The passage is configured to direct cooling liquid from the thermal exchange chamber to the pump chamber, the passage positioned at either first end or a second end of the thermal exchange chamber.



Ryu, Figure 3

376. To the extent this limitation was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on her experience, education, and training. Liquid pumps are designed with outlets through which liquid flows. In electronics cooling devices, the cooling liquid is propelled toward the heat-generating device to a thermal exchange chamber where heat transfer occurs. I have worked with and taught students the operation, design, and analysis of such systems for years. A POSA would have been motivated to use a thermal exchange chamber that includes a second passage configured to direct cooling liquid out of the thermal exchange chamber so that the fluid can circulate between the two chambers and draw heat away from the heat-generating component and distribute the heat to the ambient environment.

377. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 10 Preamble A liquid cooling system for cooling a heat-generating component of a computer, comprising;

378. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

379. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

380. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including,

381. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

382. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

383. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being positioned on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes,

384. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

385. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

386. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

387. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

388. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

389. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller;

390. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

391. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

392. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

393. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

394. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

395. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of parallel channels that are configured to direct the flow of the cooling liquid within the thermal exchange chamber;

396. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

397. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

398. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

399. As discussed in connection with claim 1, Ryu discloses this preamble. I adopt that analysis here.

400. To the extent this was not disclosed or taught by Ryu alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

401. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(h) a set of four mounting legs configured to secure the heat-exchanging interface to a heat-generating component of a computer.

402. To the extent this limitation was not disclosed or taught by Ryu, it would have been obvious to a POSA based on her experience, education, and training. In fact, the use of mounting legs to secure heat-exchanging interface to a heat-generating component is routine. This is made clear by the asserted prior art referenced in the ’196 patent, as shown below. A POSA would have been motivated to use four legs to secure the thermal exchange interface to the heat-generating component because the legs provide a uniform contact at the interface and thereby reduces thermal resistance.

403. Retaining frame 3 has four legs which are matched with four legs of brace 6.

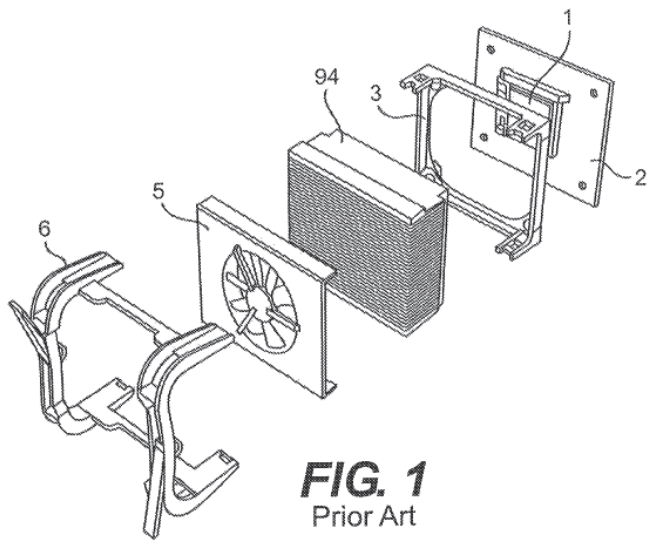


FIG. 1
Prior Art

'196 patent, Figure 1

404. To the extent that this was not disclosed or taught by Ryu, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 13: The liquid cooling system of claim 10, wherein the double-sided chassis defines a recess configured to house the stator.

405. To the extent this limitation was not disclosed or taught by Ryu, it would have been obvious to a POSA based on her experience, education, and training. In fact, the double-sided chassis of Ryu could easily be modified to include a recess to house the stator. Recesses to house stators are common and a POSA working with pumps or thermal management of electronics would have been familiar with their use. A POSA would have been motivated to use a double sided chassis with a recess to house the stator because this arrangement effectively isolates the stator from the impeller and helps the pump

efficiently direct fluid to the heated region where is removes heat and transfers the heat to the ambient environment.

406. To the extent that this was not disclosed or taught by Ryu with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

D. Ground 4 – Koga in View of Duan

407. It is my opinion that Koga in view of Duan renders claims 1, 2, and 13 of the '196 patent invalid.

Claim 1 (preamble) A liquid cooling system for cooling a heat-generating component of a computer, comprising

408. While I do not understand that the preamble of this claim is limiting, if it is limiting, then Koga discloses it. Koga is a liquid cooling system for cooling a heat-generating component of a computer.

(57) **ABSTRACT**

A cooling device has a closed circulating channel for circulating coolant, and in the channel, a radiator and a centrifugal pump of contact heat-exchanger model are provided. A heat-producing electronic component contacts with the centrifugal pump, and the coolant in the pump collects the heat off the component due to the heat exchanging function. Then the heat is dissipated from the radiator. The pump includes a pump-casing made of highly heat conductive material and an impeller. The pump casing has a heat-receiving plane formed on a face along a pump room therein, and a sucking channel is prepared between the heat-receiving plane and an inner wall of the pump room. This inner wall has a recess where protrusions extending toward the impeller or dimples are provided. The foregoing cooling device has a simple structure and can be downsized and slimmed while its cooling efficiency is improved.

Koga, Abstract

1

COOLING DEVICE AND CENTRIFUGAL PUMP TO BE USED IN THE SAME DEVICE

TECHNICAL FIELD

The present invention relates to a cooling device which cools heat-producing electronic components, such as a central processing unit (CPU), disposed in a housing by circulating coolant. It also relates to a centrifugal pump to be used in the cooling device.

Koga, column 1, lines 1-10

A first conventional cooling device has a structure as shown in FIG. **9**. Housing **100** accommodates circuit board **102**, cooler **103** and radiator **104**. Heat-producing electronic component (hereinafter referred to simply as component) **101** is mounted on board **102**. Cooler **103** exchanges the heat between component **101** and coolant, thereby cooling component **101**. Radiator **104** liberates the heat from the coolant. Pump **105** circulates the coolant through pipe **106**, and fan **107** air-cools radiator **104**.

Koga, Column 1, lines 34-42

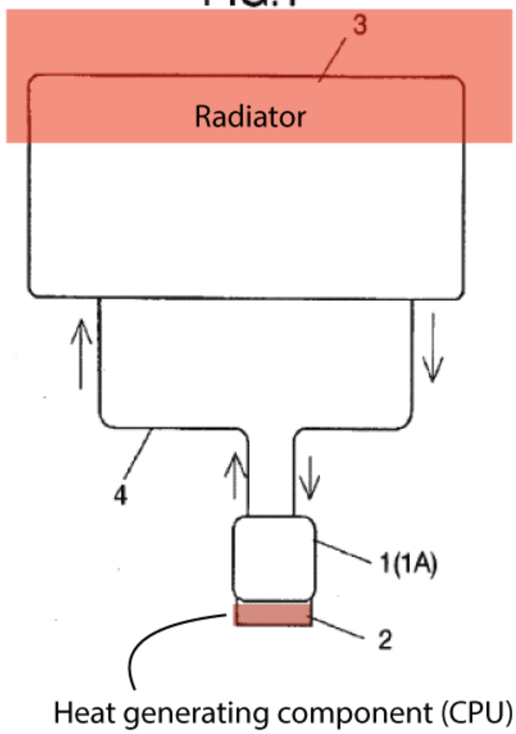
An operation of the first conventional cooling device is described hereinafter. Pump **105** discharges the coolant, which then travels through pipe **106** and arrives at cooler **103**, where the coolant collects heat off component **101** and its temperature thus rises. The coolant then travels to radiator **104**, where fan **107** air-cools forcibly the coolant, so that its temperature lowers. The coolant returned to pump **15**, and repeats the foregoing cycle. As discussed above, the coolant circulates through pipe **106**, thereby cooling component **101**.

Koga, Column 1, lines 43-51

Centrifugal pump **1** of heat exchanger model (hereinafter referred to simply as pump **1**) is an element of the cooling device. Heat-producing component **2** (hereinafter referred to simply as component) such as a CPU is, in general, a chip component having a flat surface. Pump **1** and component **2** are extremely small and mounted in a compact portable electronic apparatus such as a notebook-size computer. Radiator **3** radiates the heat collected from component **2** by coolant **41** to the outside. Closed circulating channel **4** couples pump **1** to radiator **3**, thereby circulating coolant **41**, which is liquid and preferably a water solution of propylene glycol which is harmless and used as a food additive. In the case of using aluminum or copper as a material of the casing, an anti-corrosion additive is preferably added in order to increase resistance to corrosion caused by those materials.

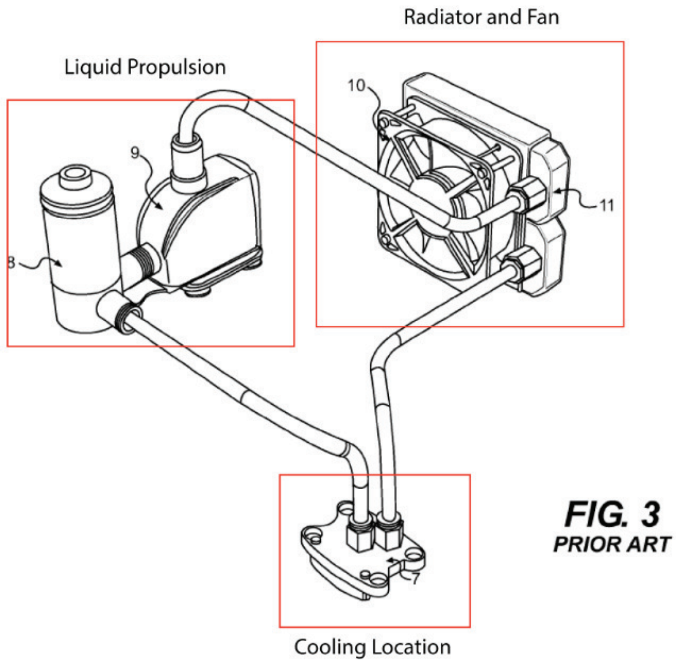
Koga, Column 4, lines 3-18

FIG.1



Koga, Figure 1

409. To the extent this was not disclosed or taught by Koga, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics. This is shown by the following figure, which was cited as prior art in the asserted patents:



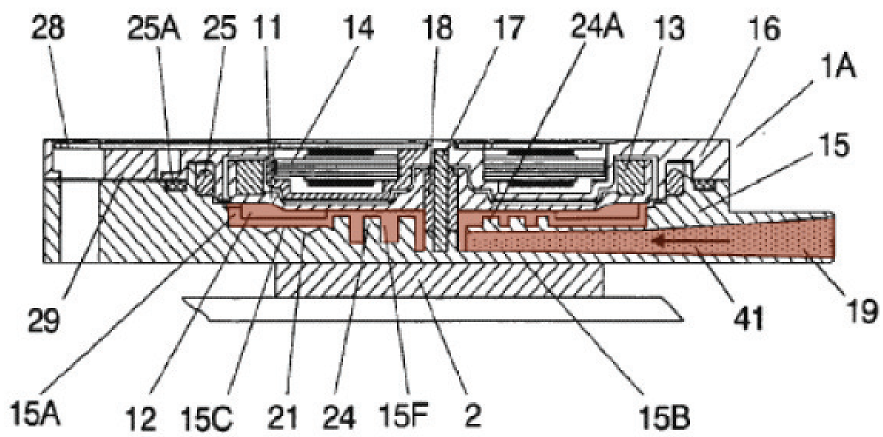
’196 Figure 3, prior art

410. To the extent that this was not disclosed or taught by Koga with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here. A POSA would have been motivated to use a liquid cooling system for removing heat from a heat generating component because liquids are excellent heat transfer fluids and are able to quickly and effectively remove thermal energy.

1(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

411. Koga discloses or teaches a “reservoir” configured to circulate liquid therethrough, as shown here. In the following figure, the black arrow indicates the flow of coolant into the reservoir of Koga.

FIG.7



Koga, Figure 7

412. To the extent this was not disclosed or taught by Koga alone, it would have been obvious in view of the experience, education, and training of a POSA. Liquid pumps such as those used to provide flow to cool electronics and heat-generating components include reservoirs through which coolant flows. A POSA would have been knowledgeable about these reservoirs and their implementation is routine in the thermal management of electronics. I have personally used such devices numerous times in my own work. A POSA would have been motivated to utilize a reservoir for circulating a cooling liquid because reservoirs are efficient and simple means of routing fluid to a heated region and thus facilitate heat removal from that region.

413. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

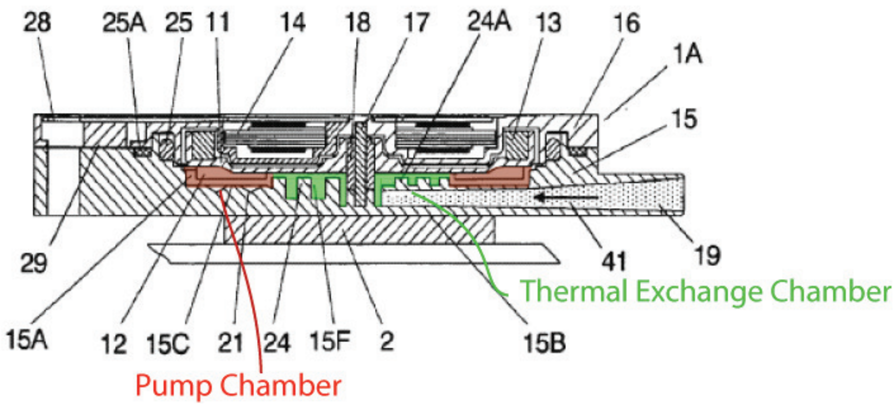
1(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being position on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes:

414. Koga discloses or teaches this limitation; it has a pump chamber that houses an impeller and is defined at least in part by an impeller cover and a double-sided chassis. The impeller is positioned on one side of the chassis and a stator of the pump is positioned on the opposite side of the chassis. The pump chamber is identified as pump room 15A as discussed here:

> Recess **15**F of the pump room is disposed one step down from radially outer wall surface **15**C of casing **15**. Cylindrical protrusions **24** extend from a bottom face of recess **15**F toward impeller **11**. Recess transversal sections **30**, **30**A, **30**B cross recess **15**F and extend from sucking channel **19** toward the center of casing **15**. Protrusions **24**A extend from the upper faces of transverse sections **30**, **30**A, **30**B.

Koga, Column 9, lines 3-9

FIG.7



Koga, Figure 7

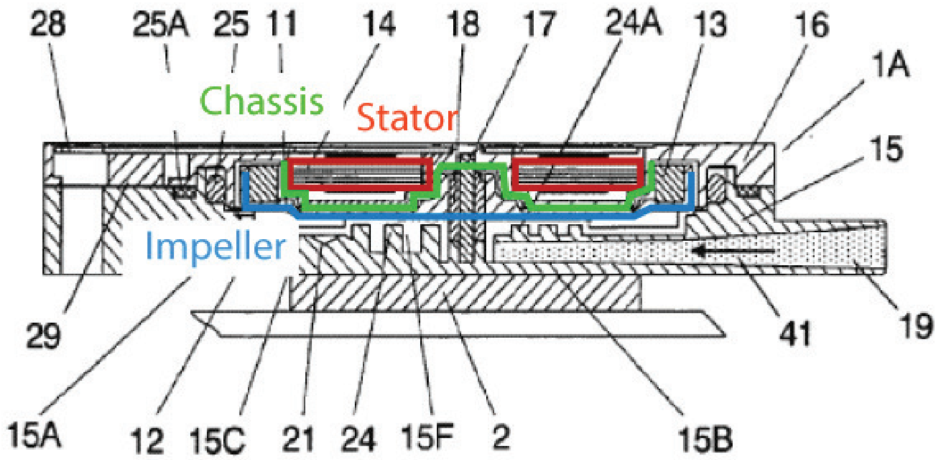
415. Koga discloses or teaches impellers that are positioned in the pump chamber, on an opposite side of a chassis than the stator. A POSA would have been motivated to use a pump chamber housing an impeller and defined by an impeller cover and a double-sided chassis with the impeller and stator positioned on opposite sides of the chassis. Such a design isolates the stator from the impeller and facilitates the routing of fluid to the heated region.

(57) **ABSTRACT**

A cooling device has a closed circulating channel for circulating coolant, and in the channel, a radiator and a centrifugal pump of contact heat-exchanger model are provided. A heat-producing electronic component contacts with the centrifugal pump, and the coolant in the pump collects the heat off the component due to the heat exchanging function. Then the heat is dissipated from the radiator. The pump includes a pump-casing made of highly heat conductive material and an impeller. The pump casing has a heat-receiving plane formed on a face along a pump room therein, and a sucking channel is prepared between the heat-receiving plane and an inner wall of the pump room. This inner wall has a recess where protrusions extending toward the impeller or dimples are provided. The foregoing cooling device has a simple structure and can be downsized and slimmed while its cooling efficiency is improved.

Koga, Abstract

FIG.7

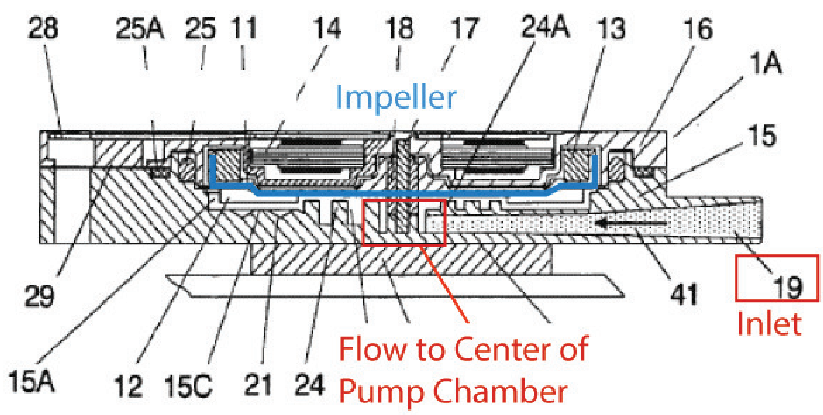


Koga, Figure 7

1(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

416. Koga discloses or teaches this limitation. It teaches an inlet defined by the impeller cover that is positioned below the center of the impeller and enables the liquid to flow to the center of the pump chamber.

FIG.7



Koga, Figure 7

417. To the extent this was not disclosed or taught by Koga, it would have been obvious based on the experience, education, and training of a POSA. Inlets to pumps provided by an inlet in the center of a pump are extremely common and ubiquitous. I have worked with such pumps numerous times in my career and these would be routine for a POSA working with pumps or the thermal management of heat-generating components. A POSA would have been motivated to incorporate an impeller cover positioned below a center of the impeller and configured to enable a cooling fluid to flow into the center of

the pump chamber. Such an arrangement is a simple and hydraulically efficient way to route fluid and reduce fluid connections and to improve heat transfer.

418. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

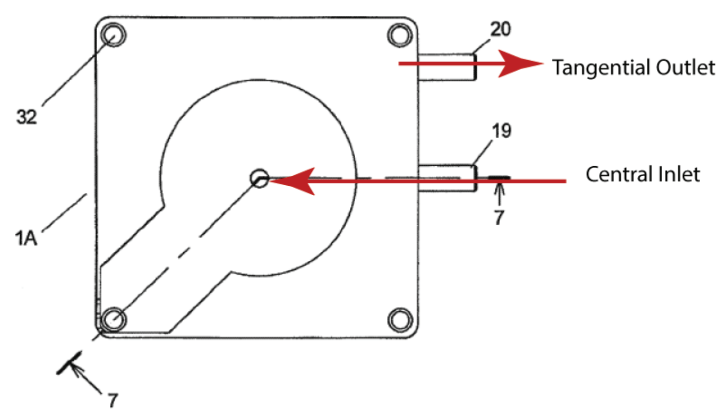
1(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller,

419. Koga discloses or teaches this limitation. It teaches an outlet defined by the impeller cover tangentially positioned to the circumference of the impeller, as shown in the following images.

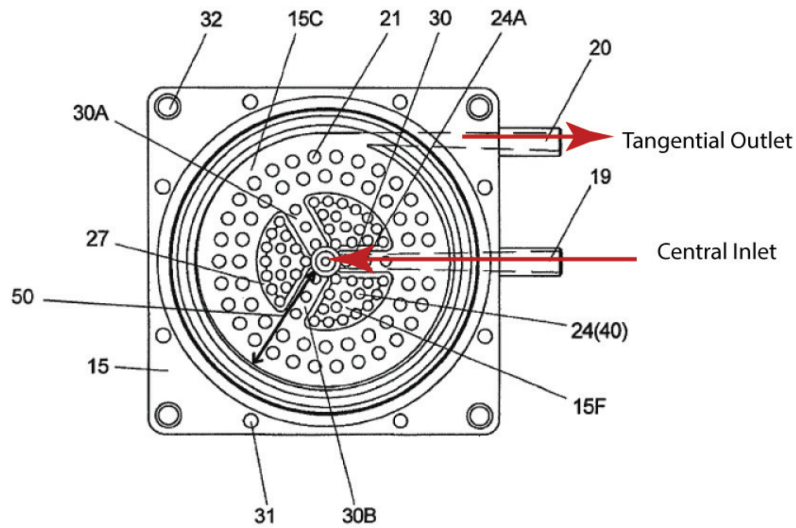
11. Sucking channel **19** sucks coolant **41**, and discharging channel **20** discharges coolant **41**. Sucking channel **19** is disposed between heat-receiving plane **15B** and inner wall face **50**.

Koga Column 8 lines 57-60

FIG.6



Koga, Figure 6



Koga, Figure 8

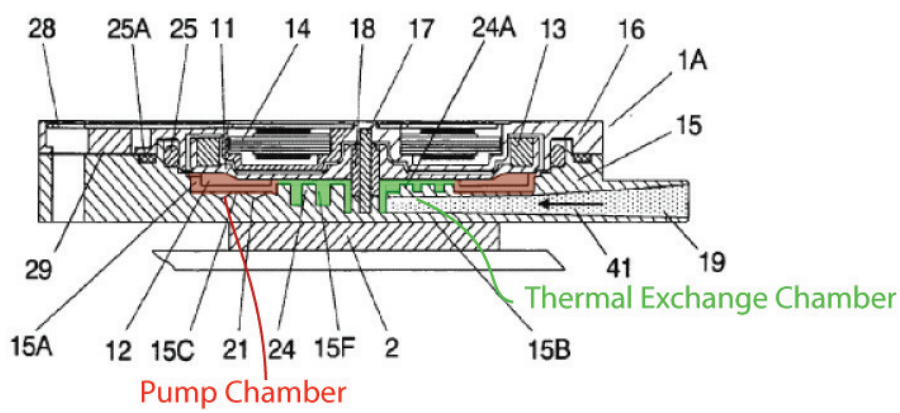
420. To the extent this was not disclosed or taught by Koga, it would have been obvious based on the experience, education, and training of a POSA. Inlets to pumps provided by an inlet in the center of a pump are extremely common and ubiquitous. I have worked with such pumps numerous times in my career and these would be routine for a POSA working with pumps or the thermal management of heat-generating components. A POSA would have been motivated to position an outlet tangential to the circumference of the impeller because this reduces hydraulic resistance and improves the pump performance.

421. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

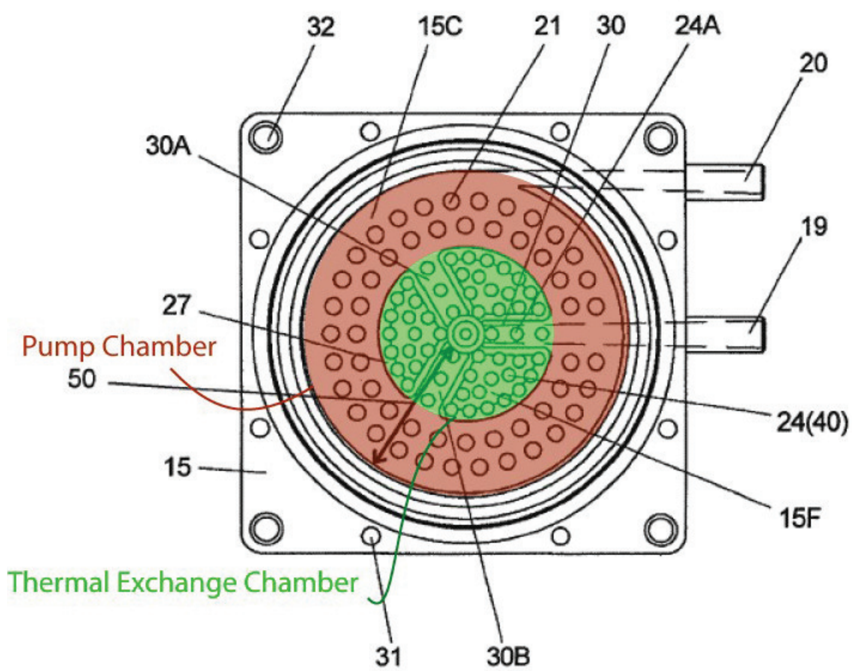
1(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

422. Koga discloses or teaches this limitation because it has a thermal exchange chamber that is disposed between the pump chamber and a heat-generating component.

FIG.7



Koga, Figure 7



Koga, Figure 8

423. To the extent this was not disclosed or taught by Koga, it would have been obvious based on the experience, education, and training of a POSA. Implementing a thermal exchange chamber between a pump chamber and a heat-generating component is commonly performed by a POSA working in thermal management of electronics. The motor region of a liquid pump houses the electric and largely stationary components of the electric motor while the pump chamber houses the rotating impeller that provides the locomotion to the fluid. A POSA would have been motivated to incorporate a thermal exchange chamber disposed between the pump chamber and the heat-generating component because the close proximity of the thermal exchange chamber and the heat-generating component would reduce thermal resistance and lower temperatures.

424. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of channels that direct the flow of the cooling liquid within the thermal exchange chamber;

425. Koga discloses or teaches this limitation; it teaches a heat-exchanging interface that forms a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a such of a heat generating component and an inner surface that defines a plurality of channels that direct

the flow of cooling liquid within the thermal exchange chamber. A POSA would have been motivated to use a heat-exchanging interface that is a boundary wall of the thermal exchange chamber and in thermal contact with a heat-generating component and with an inner surface that has a plurality of channels to direct the flow. The close proximity of the heat-exchange interface to the thermal exchange chamber and to the heat-generating component reduces the thermal resistance and lowers the temperature. In addition, use of channels increases the convective heat transfer and also reduces temperatures.

> Heat-receiving plane **15B** is formed on an outer wall face of a base wall of casing **15** along pump room **15A**, and brought into contact with component **2**, thereby collecting heat off component **2**. Heat-receiving plane **15B** is formed on the outer wall face of casing **15** substantially parallel with a revolution surface of impeller **11**. On radially outer wall sur-

Koga Column 4, lines 38-43

> In pump **1**, blades **12** of impeller **11** are disposed facing component **2**, and heat-receiving plane **15B** is formed to have a surface complementary to the upper surface of component **2**, so that pump room **15A** receives the heat via heat-receiving plane **15B**. FIG. **3** shows that pump **1** is disposed above component **2**; however pump **1** can be placed below component **2**, or those elements can be laterally placed depending on the placement of component **2**.

Koga, Column 5, lines 30-37

> channel **20** discharges coolant **41**. Sucking channel **19** is disposed between heat-receiving plane **15B** and inner wall face **50**.

Koga, Column 6, lines 58-60

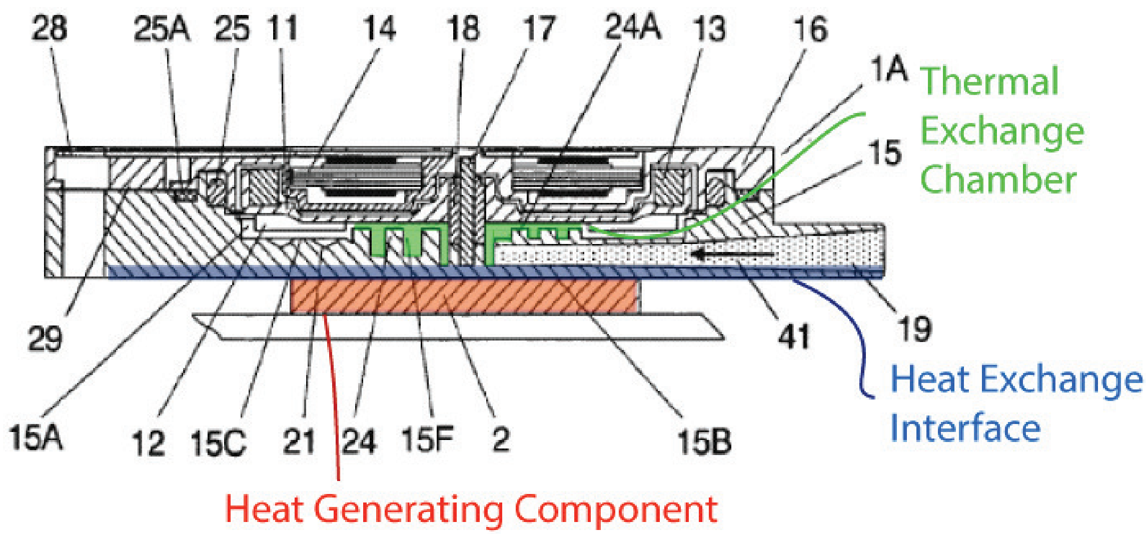
As described above, pump **1** includes casing **15** made from material having a high thermal conductivity, and open impeller **11** having blades **12**. Inner wall face **15**C has recess **15**E, and protrusions **24** extend from the bottom face of recess **15**E toward impeller **11**. This structure allows reducing the thickness of pump **1** and increasing the surface area of interior wall of the pump room, so that a heat collecting efficiency increases. The shape of heat-receiving plane **15**B and the shape of an upper surface of component **2** complement each other three-dimensionally, so that sucking channel **19** does not extend over component **2**. This structure allows heat-receiving plane **15**B and the upper surface of component **2** to solidly contact with each other, so that the heat can be transferred efficiently.

Koga, Column 8, lines 40-53

As described above, pump **1**A includes casing **15** made of material having a high thermal conductivity, and open impeller **11** having blades **12**. Radially outer wall surface **15**C surrounds recess **15**F, and protrusions **24** extend from the bottom face of recess **15**F toward impeller **11**. This structure allows reducing the thickness of the pump and increasing the surface area of interior wall of the pump room, so that a heat collecting efficiency increases. Further, transverse sections **30**, **30**A and **30**B positively guide coolant **41** sucked to near the center of recess **15**F. Protrusions **24** thus positively transferred the heat to coolant **41**, so that the heat collecting efficiency further increases. The shape of heat-receiving plane **15**B and the shape of an upper surface of component **2** complement each other three-dimensionally, so that sucking channel **19** does not extend over component **2**. This structure allows heat-receiving plane **15**B and the upper surface of component **2** to solidly contact with each other, so that the heat can be transferred efficiently.

Koga, Column 10, lines 23-39

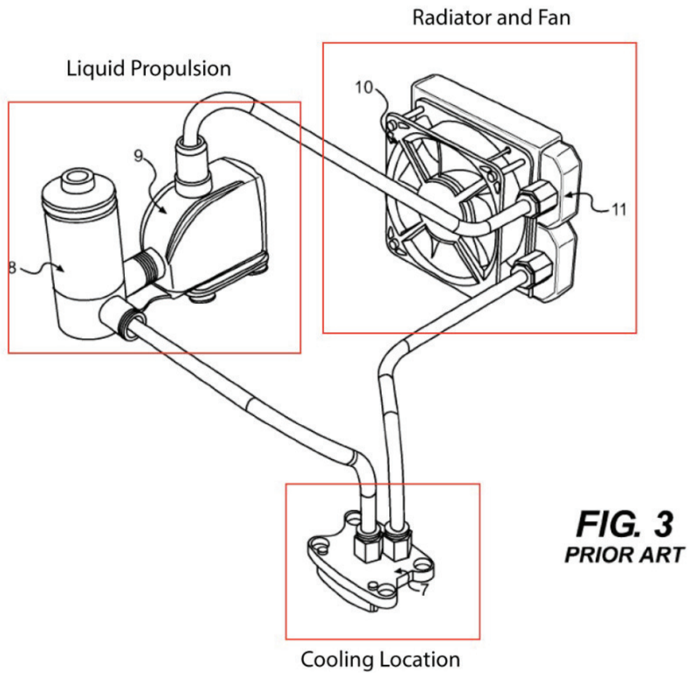
FIG.7



1(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

426. To the extent this was not disclosed or taught based on Koga alone, it would have been obvious based on the experience, education, and training of a POSA. It would have been a routine exercise for a POSA working on thermal management of electronics to use a heat radiator that is spaced apart from a reservoir and fluidly coupled with the reservoir by tubing. In fact, I have worked with such systems numerous times, and I instruct undergraduate and graduate students on the design and analysis of such systems. This is supported by the following image, which was provided as prior art in the asserted patents. A POSA would have been motivated to use a radiator adapted to pass cooling liquid

therethrough with the radiator coupled to the reservoir. Such an arrangement allows the heat from the heat-generating component to be removed from the vicinity of the heat-generating location and transferred to the ambient environment in an efficient manner.



’196 patent, Figure 3

427. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

1(h) a first passage fluidly coupling the pump chamber and the thermal exchange chamber, wherein the first passage is configured to direct the cooling liquid from the outlet of the pump chamber into the thermal exchange chamber between a first end and a second end of the thermal exchange chamber.

428. Koga in view of Duan renders this limitation obvious. This is because Duan discloses or teaches this limitation as I have explained above in Ground 1. Thus, this limitation would have been obvious based on the combination of Koga and Duan for reasons I have already articulated in my discussion of Ground 1 regarding Duan's disclosure of this limitation. I adopt that prior analysis here. As I have already mentioned, a POSA would have been motivated to utilize a passage to fluidly couple the pump chamber and the thermal exchange chamber. This allows the cooling liquid to pass from the pump chamber to the thermal exchange chamber. Positioning the passage between the first and second ends of the thermal exchange chamber allows the cooling fluid to more directly impact the heat transfer region and facilities a more uniform temperature.

Claim 2: The cooling system of claim 1, wherein the thermal exchange chamber includes at least one second passage configured to direct the cooling liquid out of the thermal exchange chamber, the at least one second passage is positioned at either a first end or a second end of the thermal exchange chamber.

429. Koga in view of Duan renders this limitation obvious. This is because Duan discloses or teaches this limitation as I have explained above in Ground 1. Thus, this limitation would have been obvious based on the combination of Koga and Duan for reasons I have already articulated in my discussion of Ground 1 regarding Duan's disclosure of this limitation. I adopt that prior analysis here. As already stated, a POSA would have been motivated to use a thermal exchange chamber that includes a second passage configured to direct cooling liquid out of the thermal exchange chamber so that the fluid can

circulate between the two chambers and draw heat away from the heat-generating component and distribute the heat to the ambient environment.

Claim 10 Preamble A liquid cooling system for cooling a heat-generating component of a computer, comprising;

430. As discussed in connection with claim 1, Koga discloses this preamble. I adopt that analysis here.

431. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

432. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including,

433. As discussed in connection with claim 1, Koga in view of Duan renders this limitation obvious. I adopt that analysis here.

10(b) a pump chamber housing an impeller and defined at least in part by an impeller cover and a double-sided chassis, the impeller being positioned on one side of the chassis and a stator of the pump is positioned on an opposite side of the chassis, wherein the pump chamber includes,

434. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

435. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

436. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(c) an inlet defined by the impeller cover positioned below a center of the impeller configured to enable a cooling liquid to flow into the center of the pump chamber,

437. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

438. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

439. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(d) an outlet defined by the impeller cover positioned tangentially to the circumference of the impeller;

440. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

441. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

442. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(e) a thermal exchange chamber configured to be disposed between the pump chamber and a heat-generating component when the system is installed on a heat-generating component;

443. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

444. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

445. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(f) a heat-exchanging interface forming a boundary wall of the thermal exchange chamber, the heat-exchanging interface has an outer surface configured to be placed in thermal contact with a surface of a heat-generating component and an inner surface that defines a plurality of parallel channels that are configured to direct the flow of the cooling liquid within the thermal exchange chamber;

446. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

447. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

448. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(g) a heat radiator adapted to pass the cooling liquid therethrough, the heat radiator being fluidly coupled to the reservoir via fluid conduits, the heat radiator being configured to dissipate heat from the cooling liquid;

449. As discussed in connection with claim 1, Koga discloses or teaches this limitation. I adopt that analysis here.

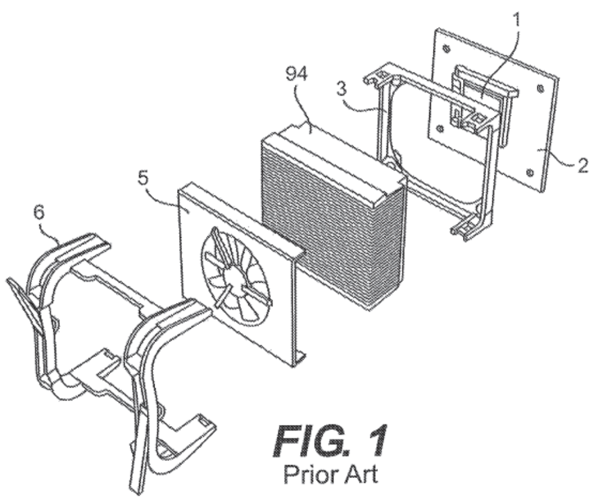
450. To the extent this was not disclosed or taught by Koga alone, it would have been obvious to a POSA based on their experience, education, and training as I already discussed for Claim 1. I incorporate that discussion here.

451. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

10(h) a set of four mounting legs configured to secure the heat-exchanging interface to a heat-generating component of a computer.

452. To the extent this limitation was not disclosed or taught by Koga, it would have been obvious to a POSA based on her experience, education, and training. In fact, the use of mounting legs to secure heat-exchanging interface to a heat-generating component is routine. This is made clear by the asserted prior art referenced in the '196 patent, as shown below. A POSA would have been motivated to use four legs to secure the thermal exchange interface to the heat-generating component because the legs provide a uniform contact at the interface and thereby reduces thermal resistance.

453. Retaining frame 3 has four legs which are matched with four legs of brace 6.



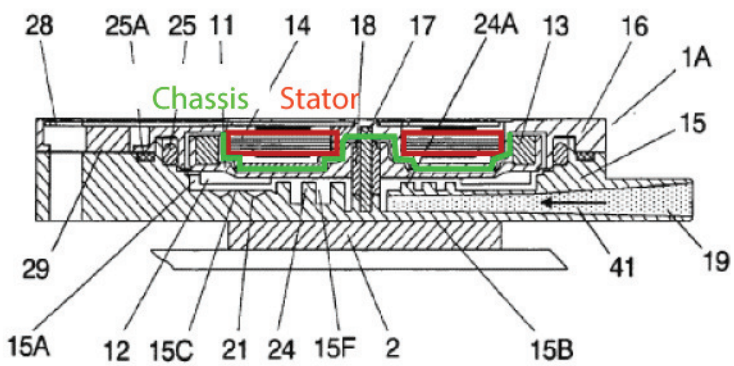
'196 patent, Figure 1

454. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

Claim 13: The liquid cooling system of claim 10, wherein the double-sided chassis defines a recess configured to house the stator.

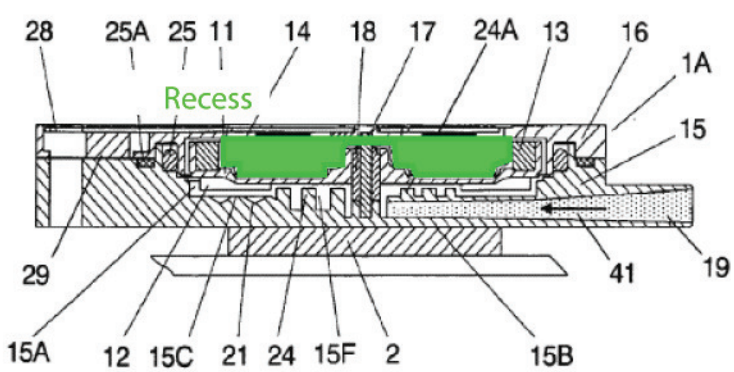
455. Koga discloses or teaches this limitation. It teaches a double-sided chassis that defines a recess configured to hold a stator, as shown in the following images.

FIG.7



Koga, Figure 7

FIG.7



Koga, Figure 7

456. To the extent this claim was not disclosed or taught by Koga alone, it would have been obvious based on the experience, education, and training of a POSA. In fact, I have worked with numerous pumps like that described in Shin with a double-sided chassis that defines a recess to house the stator. A POSA would have been motivated to use a double sided chassis with a recess to house the stator because this arrangement effectively isolates the stator from the impeller and helps the pump efficiently direct fluid to the heated region where is removes heat and transfers the heat to the ambient environment.

457. To the extent that this was not disclosed or taught by Koga, with the knowledge of a POSA, it would have been obvious based on Duan for reasons I have already articulated in my discussion of Ground 1. I adopt that prior analysis here.

IX. ANALYSIS OF VALIDITY OF THE ’601 PATENT PURSUANT TO 35 U.S.C. § 103

458. I have considered the following prior art and their combinations in forming my opinions on invalidity of claims 1, 6, 11, and 12 of the ’601 patent pursuant to 35 U.S.C. § 103:

- JP 2002-151638 (Shin)
- U.S. Patent 6,019,165 (Batchelder)
- U.S. Patent 6,915,653 (Nakano)
- ZL 02241576.9Y (Yu)
- KR 2003-0031027 (Ryu)

459. It is my opinion that claims 1, 6, 11, and 12 of the ’601 patent are invalid by obviousness under the following grounds:

Ground	Combination
1	Shin in view of Batchelder (Claims 1, 6, 11, and 12)
2	Shin in view of Batchelder and further in view of Nakano (Claim 11)
3	Batchelder in view of Shin (Claims 1, 6, 11, and 12)
4	Batchelder in view of Shin and further in view of Nakano (Claim 11)
5	Yu in view of Batchelder (Claims 1, 6, 12)
6	Yu in view of Batchelder and further in view of Nakano (Claim 11)
7	Ryu in view of Batchelder (Claims 1, 6, 12)
8	Ryu in view of Batchelder and further in view of Nakano (Claims 11)

A. Ground 1 – Shin in View of Batchelder

460. It is my opinion that Shin, in view of Batchelder and in view of the education, experience, and training of a POSA renders claims 1, 6, 11, and 12 of the ’601 patent invalid.

Claim 1 preamble: A cooling system for a computer system processing unit, comprising;

461. I do not understand the preamble of claim 1 to be limiting, but to the extent that it is, Shin discloses the preamble. Shin teaches a cooling system for a computer system processing units, as evident from the following.

462. The title of Shin is “COOLING DEVICE FOR ELECTRONIC EQUIPMENT”

463. The abstract of Shin clearly states that it is a liquid cooling system. The abstract states “*A cooling structure for compactly mounting a liquid cooled heat sink and pump inside a case.*”

464. Shin makes clear that it is intended to be used for cooling electronic components positioned on the motherboard of a computer system; as evidenced by the following representative but non-exhaustive passages.

[0001]
[Technical field of the invention] The present invention pertains to a cooling structure for liquid cooling of heat generating electronic circuit components such as LSI chips installed on a wiring board, relating in particular to a cooling structure for compactly mounting a liquid cooled heat sink and pump.

Shin [0001]

[Means for solving the problem] To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink.

Shin [0007]

[0008] Furthermore, the pump is secured to the top part of the liquid cooled heat sink, forming a structure that allows the pump and liquid cooled heat sink to be handled as an integral structure.
[0009] Furthermore, a structure is formed wherein the liquid coolant discharge section of the pump is directly connected to the liquid cooled heat sink by means of a pipe, etc.
[0010] Furthermore, an arrangement is adopted whereby the pump operates from a direct current power supply.
[0011] Moreover, a structure is formed whereby the pump is secured to the liquid cooled heat sink across a vibration absorption member or the like.
[0012]

Shin [0008-0011]

[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin [0012]

[0013] In the present embodiment example, a structure is employed whereby the pump 5 is secured to the liquid cooled heat sink 4 across a vibration absorbing member 19. Thus, a structure is formed whereby the vibration of the pump 5 does not readily have a direct effect on the CPU or other electronic component. The pump 5 is connected to the

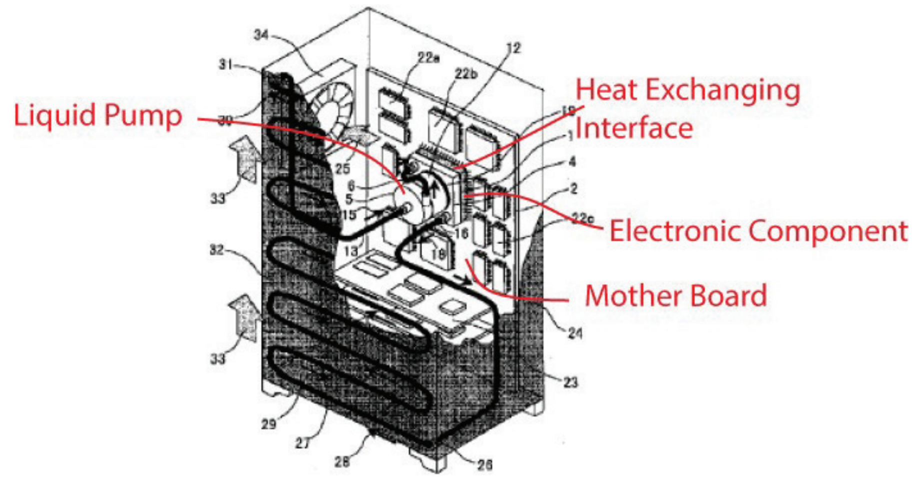
Shin [0013]

[0030] Furthermore, an integral component kit comprising this pump and liquid cooled heat sink can be installed instead of an air cooled heat sink with fan as frequently used in conventional personal computers and the like, making it possible to adopt a liquid cooling system into electronic devices without difficulty. If the power supply of the pump is compatible with the fan power supply for an air cooled heat sink with fan, the adoption of course becomes even easier.

Shin [0030]

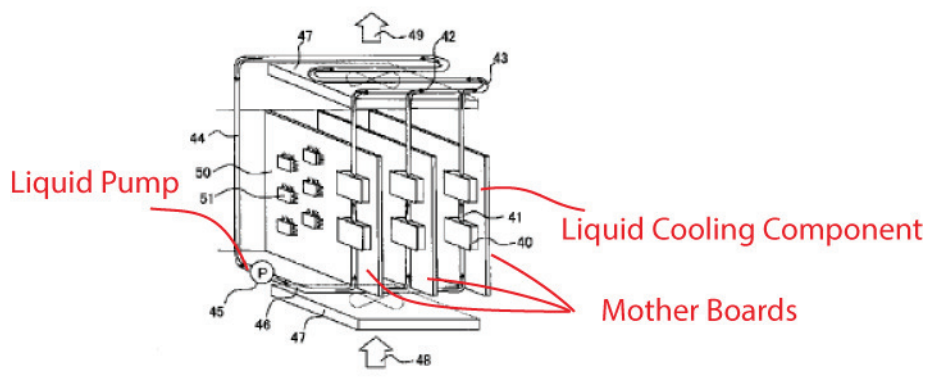
[Claim 1] A cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on said wiring board, a liquid cooled heat sink installed on said heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, characterized in that said pump is installed on the top part of said liquid cooled heat sink.

Shin, Claim 1



Shin, Figure 3

FIG. 4



Shin, Figure 4

465. To the extent this preamble was not disclosed or taught by Shin, it would have been obvious in view of the knowledge of a POSA. Liquid cooling systems for electronic components on a motherboard of a computer system are commonly encountered by POSAs working on thermal management of electronics. This is shown by the following figures, which were cited as prior art in the asserted patents:

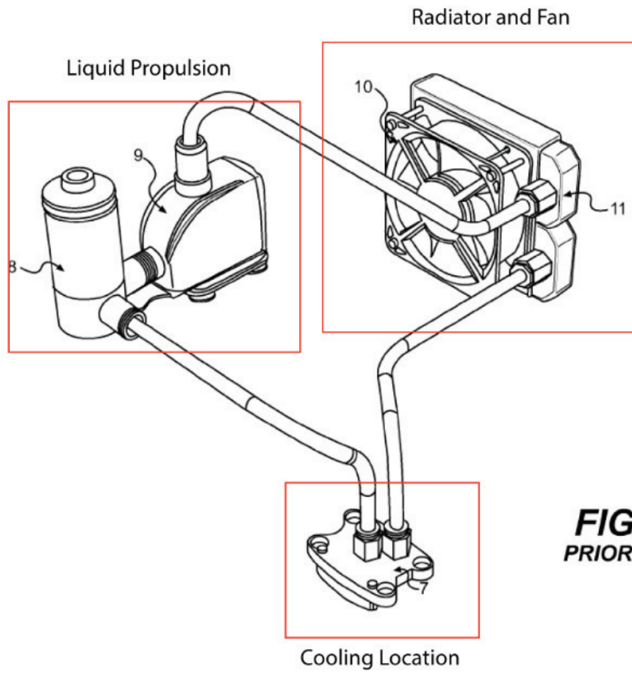


FIG. 3
PRIOR ART

’601 Figure 3, prior art

466. Further, to the extent that the preamble was not disclosed or taught by Shin in view of the knowledge of a POSA, it would have been obvious in view of Batchelder.

467. For example, in the abstract, Batchelder discusses its use in cooling electronics using a liquid cooling system.

SUMMARY OF THE INVENTION

The primary objective of this invention is to provide a low cost high reliability heat exchange apparatus that incorporates a composite substrate containing flow channels and a heat transfer fluid, providing low thermal resistance cooling to high density heat sources.

A further objective of this invention is to provide a design for cooling electronic components that is compatible with the geometry and manufacturing tooling associated with the passive spreader plate heat sinks currently in general use.

A further objective of this invention is to provide an active spreader plate with no moving or rotary mechanical seals.

A further objective of this invention is to provide a heat sink design for electronic components that uses a single motor to impel atmospheric motion and the motion of an additional heat transfer fluid.

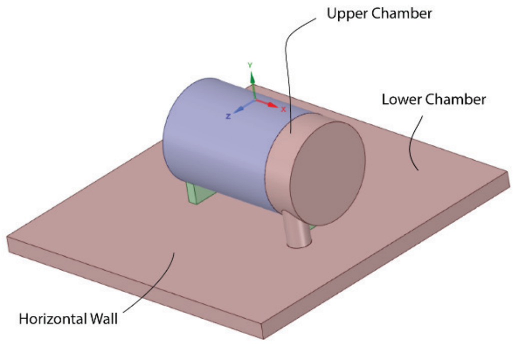
A further objective of this invention is to provide an active spreader plate without hoses or fluid couplings.

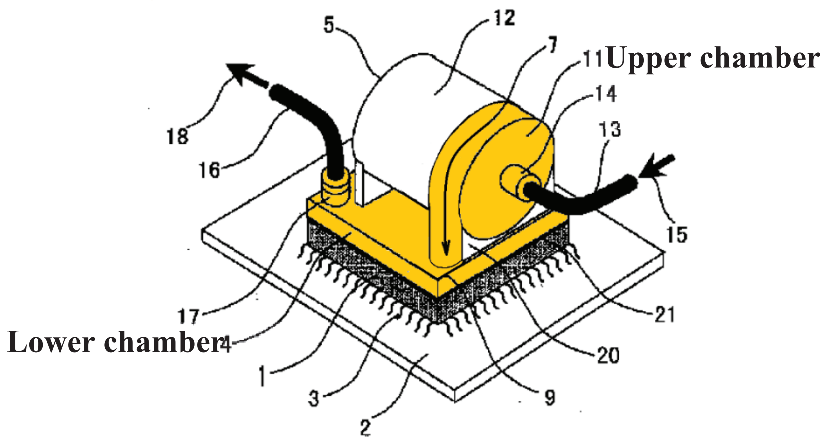
Batchelder Col. 2, lines 39-57.

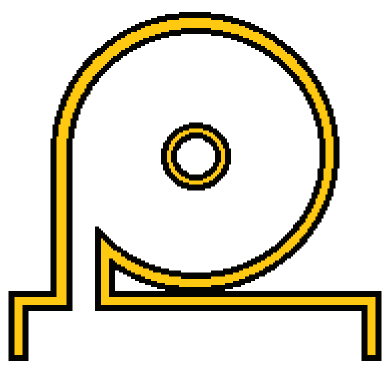
468. Batchelder further discusses cooling computer electronic components at 2:29-35; 5:64-67; and 6:1-5; as examples. A POSA would have been motivated to use a cooling system for a computer system processing unit in order to remove heat and maintain safe CPU temperatures.

1(a) A reservoir configured to circulate a cooling liquid therethrough the reservoir including:

469. Shin (as modified) renders obvious a reservoir that is configured to circulate a cooling liquid therethrough, as I have already opined above. I adopt that prior analysis here.



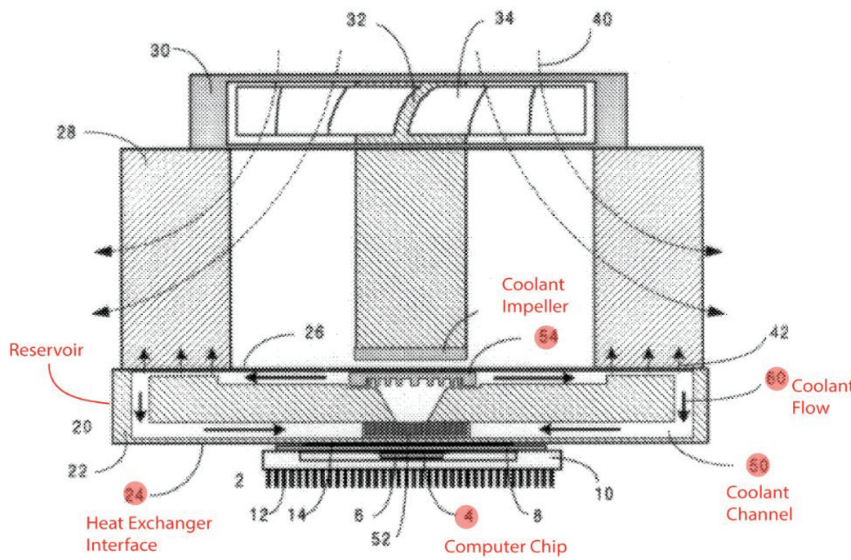




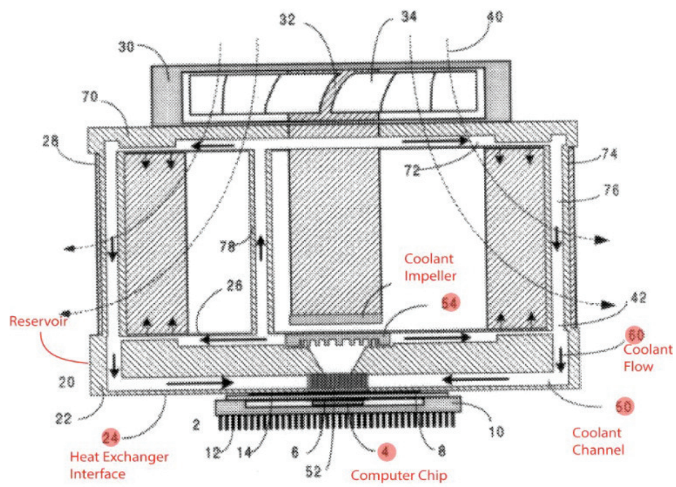
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

470. To the extent this limitation was not disclosed or rendered obvious by Shin in view of the knowledge of a POSA, it would have been obvious based on a combination of Shin and Batchelder. Batchelder discloses a reservoir, through which coolant flows, as shown in

the following images. A POSA would have been motivated to circulate cooling liquid through the reservoir because such an arrangement is an efficient way to bring cooling liquid from the pump to the heated region and thereby transfer heat from the heat-generating component into the cooling fluid. In addition, using a reservoir to route fluid reduces the number of fluid couplings, the potential for leaks and improves the performance of the system.



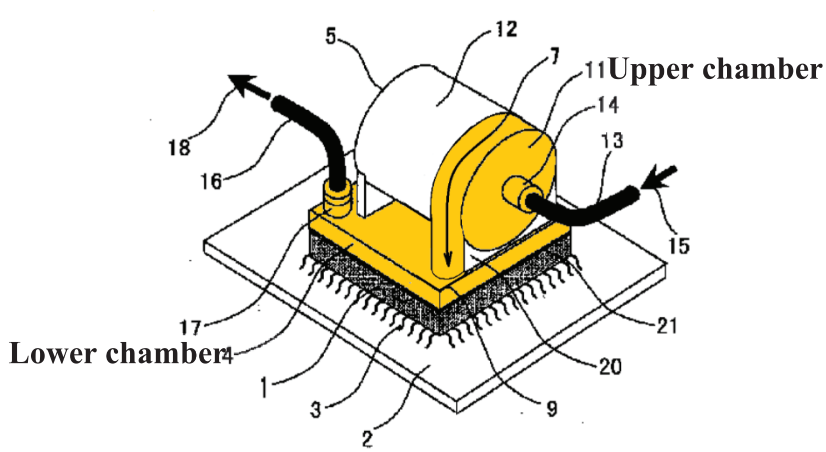
Batchelder, Figure 2



Batchelder, Figure 5

1(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls

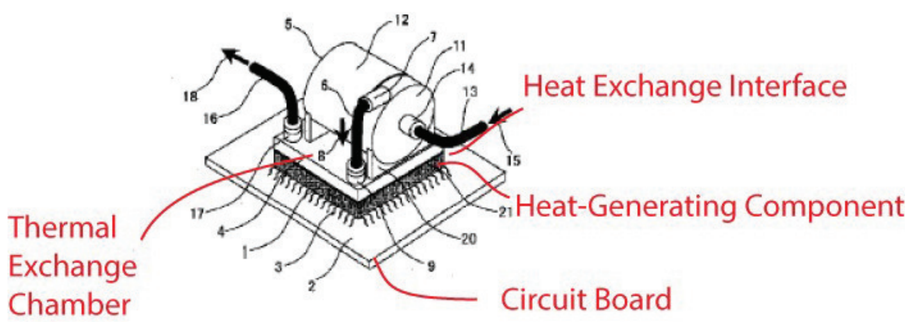
471. Shin discloses an upper and a lower chamber wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls. The upper chamber of Shin is shown here:



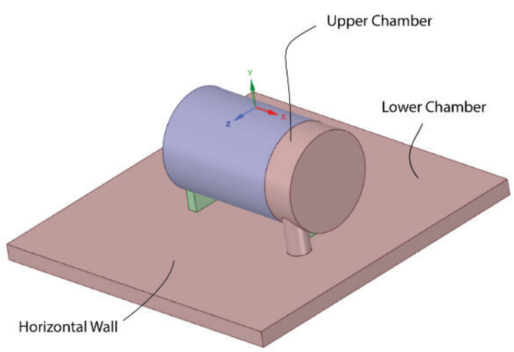
Shin, Figure 2 (Modified)

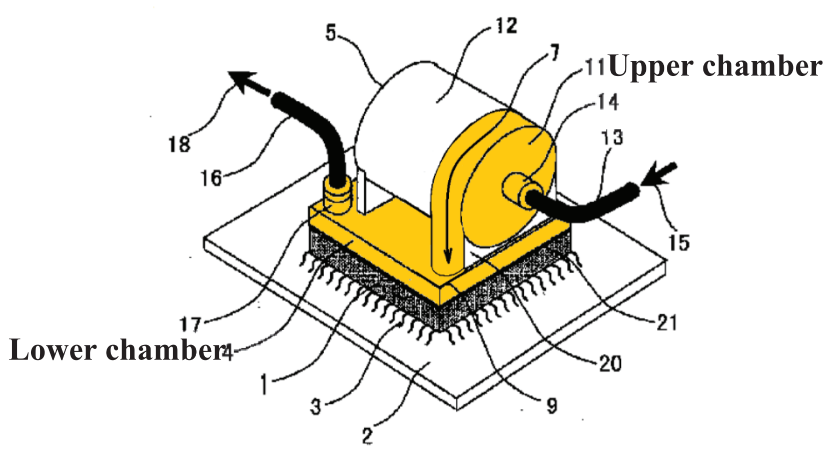
472. The lower chamber of Shin (thermal exchange chamber) is identified in the following image.

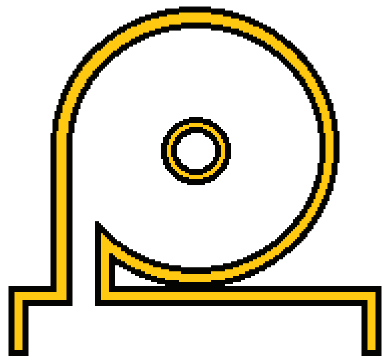
FIG. 2



Shin, Figure 2 (with the upper and lower chambers modified as follows)



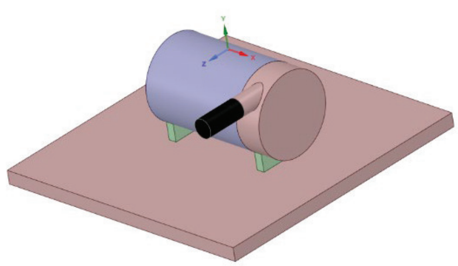




(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

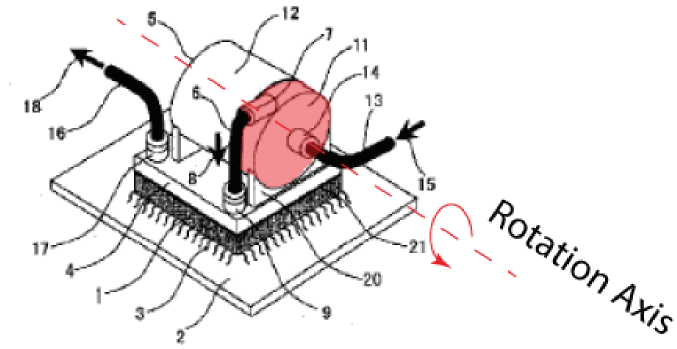
473. To the extent that Shin's reservoir is not the claimed reservoir, it would have been obvious to a POSA to modify Shin as discussed below.

474. A POSA would have been motivated to rotate the pump of Shin 90 degrees to improve its thermal and hydraulic performance, as shown in the following image. With such a rotation, the reservoir of Shin would possess the claimed upper and lower chambers with the chambers vertically spaced apart. The following three images show the original and rotated orientation of the upper chamber of the two-chamber reservoir of Shin.

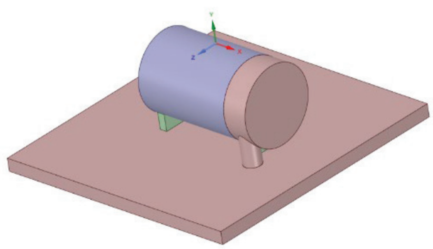


Shin Original Orientation

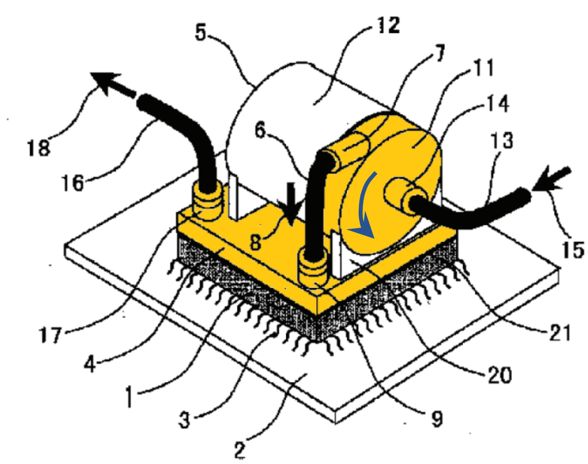
FIG. 2

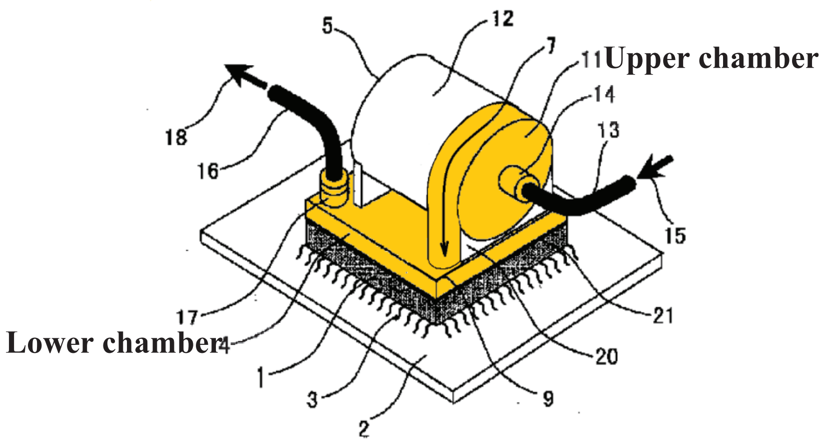


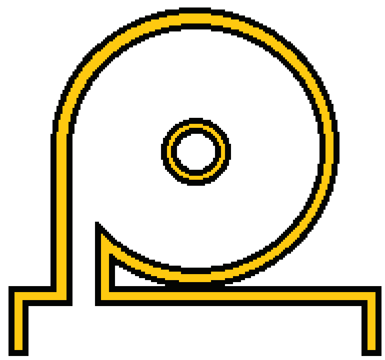
Shin, Figure 2 showing rotation of pump chamber



Shin Rotated Orientation

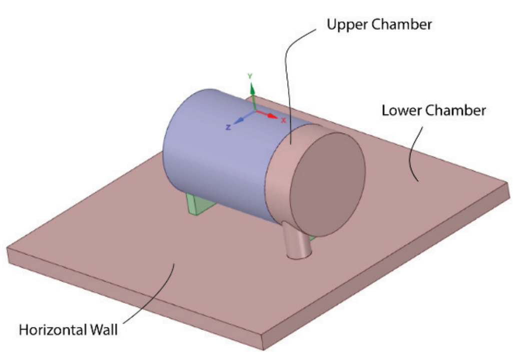




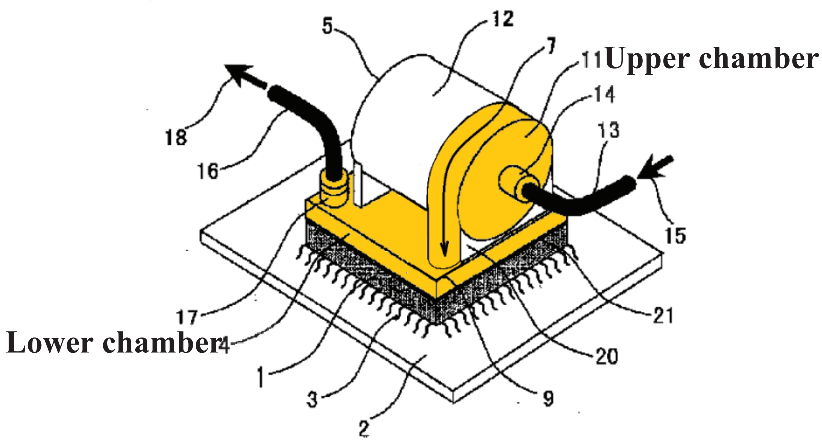


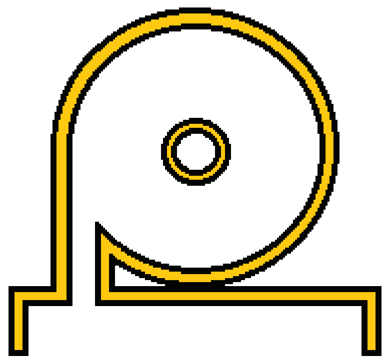
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

475. After this simple rotation, the two-chamber reservoir of Shin has an upper chamber and a lower chamber and the chambers that are vertically spaced, as shown here:



Shin – rotated with annotation

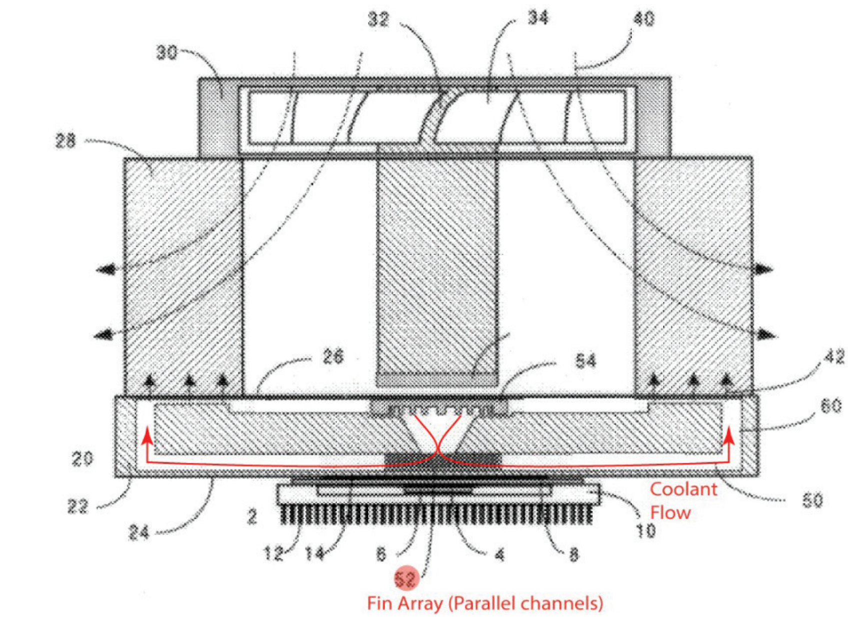




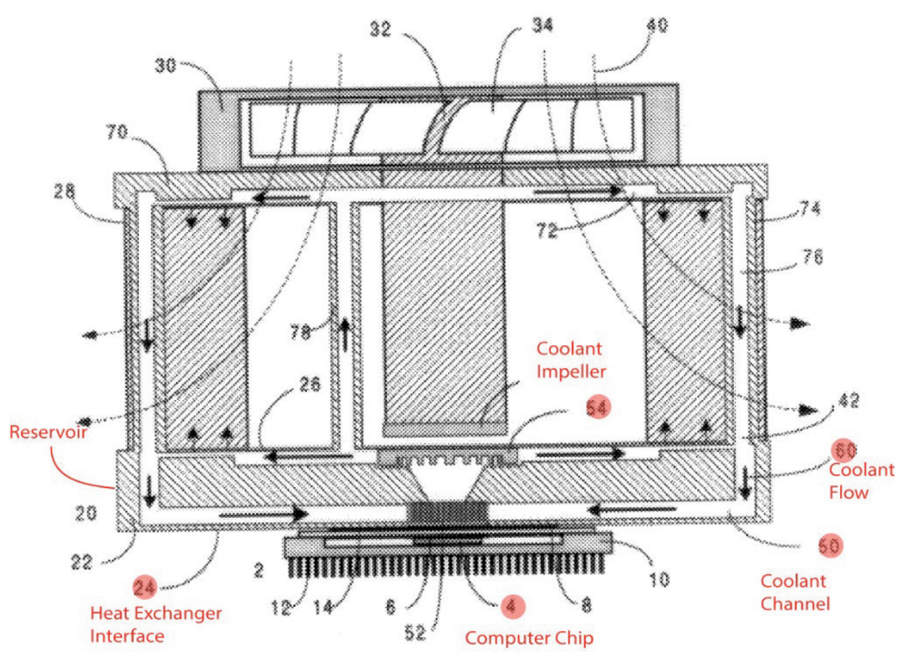
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

476. Rotating a cylindrical liquid pump would have been a trivial and routine exercise for a POSA. I have reoriented dozens or hundreds of pumps in my career by rotation. A POSA would have known that rotating a pump would lead to expected and successful results. Furthermore, a POSA would have been motivated to reorient the pump as shown below because it would eliminate a tubing connection and two potential locations for leaks. Additionally, directing the fluid from the pump to the lower chamber would improve heat transfer and performance of the system. It also simplifies the assembly and the system and reduces the number of components. The practice of reducing parts in a designed assembly is standard for engineers and follows the principles of Design For Manufacturability and Assembly (DFMA).

477. To the extent this claim is not evident based on Shin, in view of the knowledge of a POSA, it would have been obvious in light of Batchelder. Batchelder teaches the claimed reservoir, as shown here:

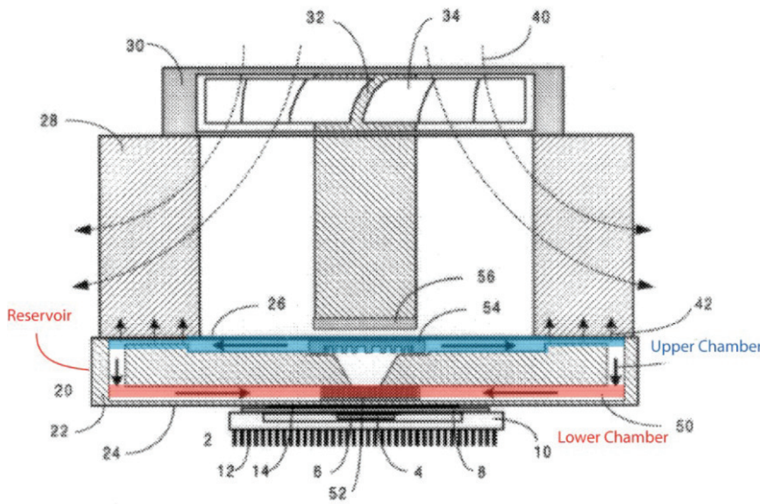


Batchelder, Figure 2

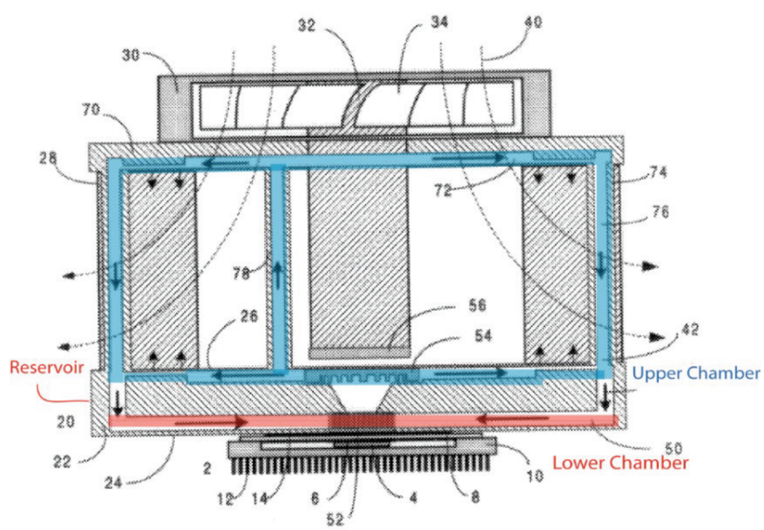


Batchelder, Figure 5

478. As seen, Batchelder's reservoir comprises both an upper chamber and a lower chamber, as shown below. A POSA would have been motivated to use an upper and a lower chamber of a reservoir that are vertically displaced and each surrounding by boundary walls. This arrangement is a simplified way to route fluid to the heated region. The vertical arrangement reduces the space occupied by the cooling system and simplifies assembly of the cooling system to the electronic system.



Batchelder, Figure 2

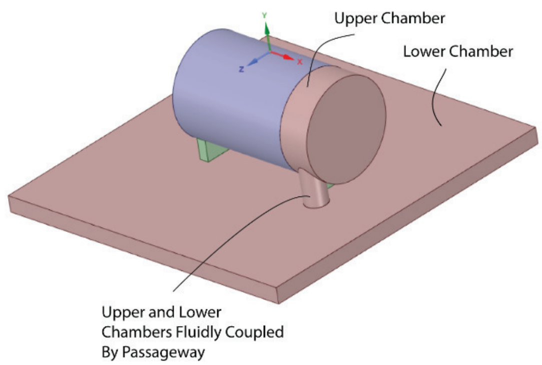


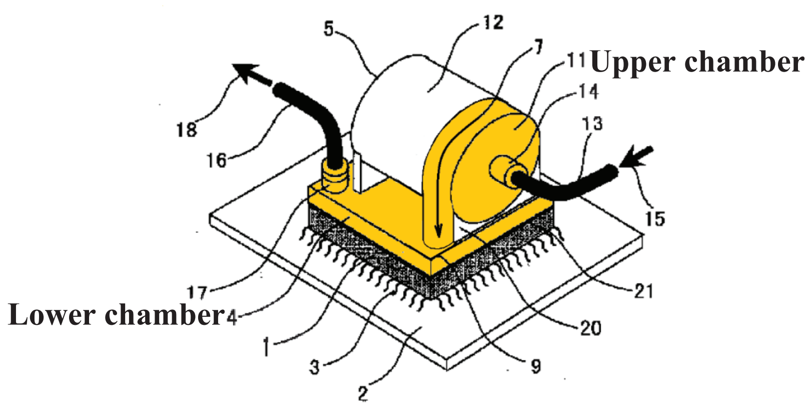
Batchelder, Figure 5

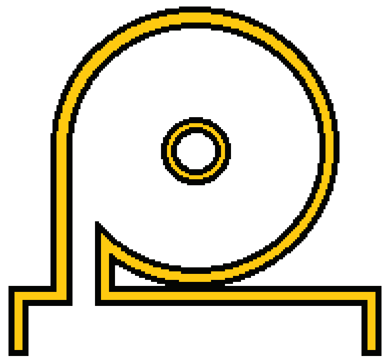
1(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber

479. The thus-modified Shin discloses or teaches this limitation, it possesses a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber.

480. As shown in the below images, the modified Shin system has an upper chamber and a lower chamber that are fluidly coupled by one or more passageways:



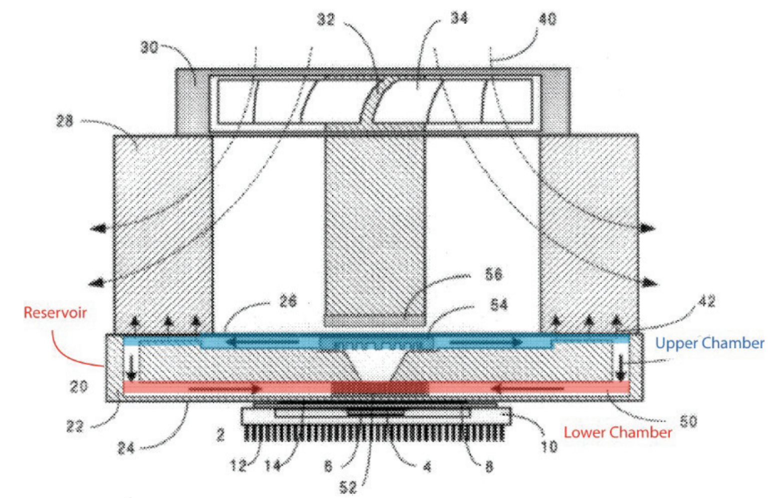




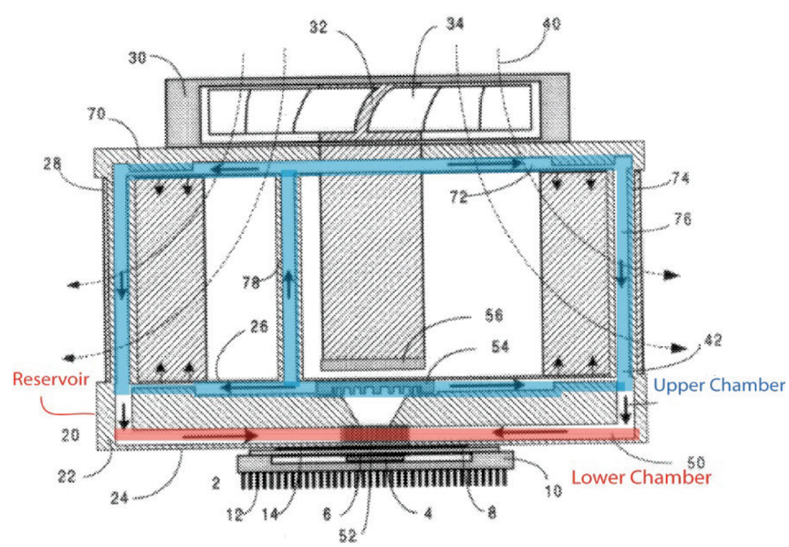
(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

481. To the extent this was not disclosed or taught based on Shin, it would have been obvious to a POSA in view of their experience, education, and training. To couple two fluid chambers by one or more passages would have been evident and trivial for a POSA. I have worked with dual chamber reservoirs before, and I instruct students on their analysis and design (both undergraduate and graduate students). In addition, a POSA would have known that it is advantageous to position a fluid passage central to the lower chamber, because the fluid entering the lower chamber would be at a colder temperature, thereby ensuring the most efficient heat transfer. Since computer chips are typically hottest at their center, a POSA would have known that the coldest liquid should be directed thereto. I have personally instructed undergraduate and graduate students on this issue, related to cooling computer systems. A POSA would have been motivated to use a passage that couples the lower and upper chambers of a reservoir where the passage is substantially central to the lower chamber. Such an arrangement is a simple and hydraulically efficient way to route liquid to the heat generating region; it shortens the flow path and improves hydraulic performance.

482. To the extent this was not made obvious by Shin, in view of the knowledge of a POSA, it would have been obvious in view of Batchelder. Batchelder discloses a two-chamber reservoir that are fluidly connected by a passageway, as shown here, where one of the passageways is centrally located.

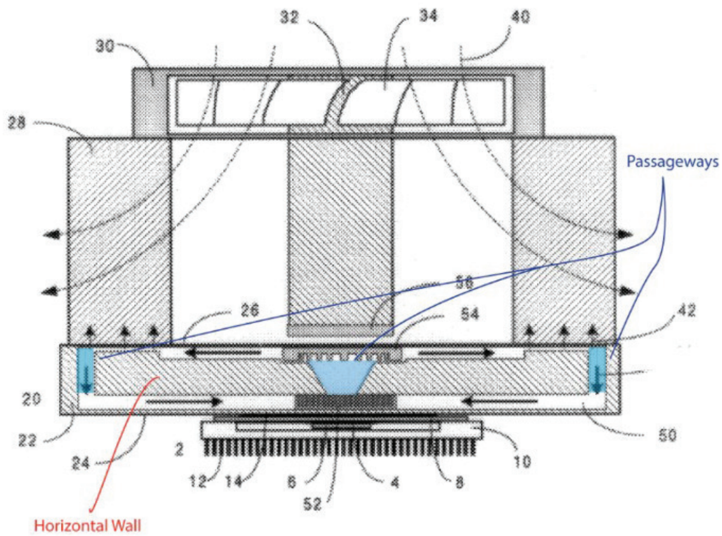


Batchelder, Figure 2



Batchelder, Figure 5

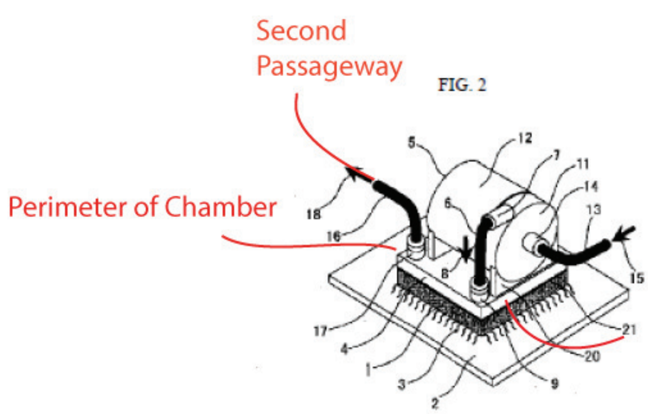
483. The passageways that fluidly couple the upper and lower chambers are shown here.



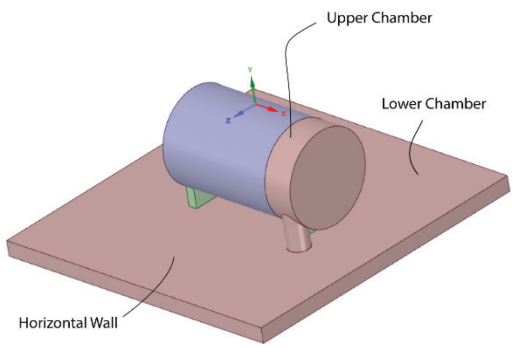
Batchelder, Figure 2

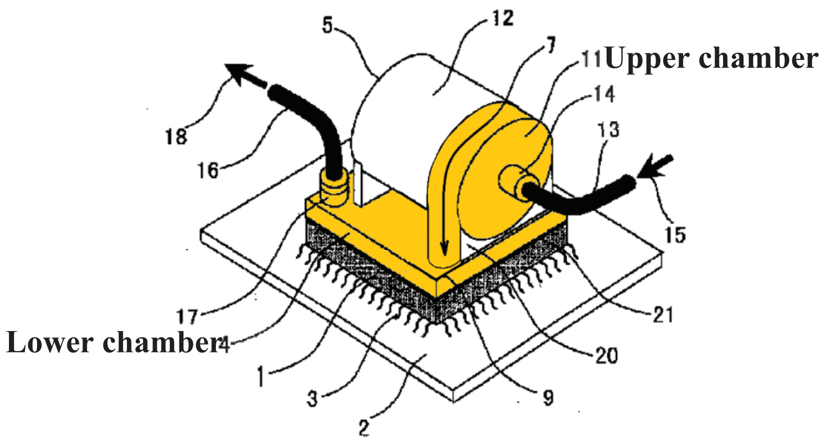
1(d) a second passage positioned at a perimeter of the lower chamber;

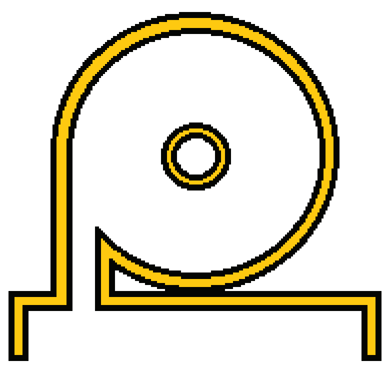
484. Shin also discloses a second passage positioned at a perimeter of the lower chamber, as shown here. The figure shows that it is positioned at a perimeter of the lower chamber (near the second end of the thermal exchange chamber).



Shin, Figure 2 (with the upper and lower chambers modified as follows)



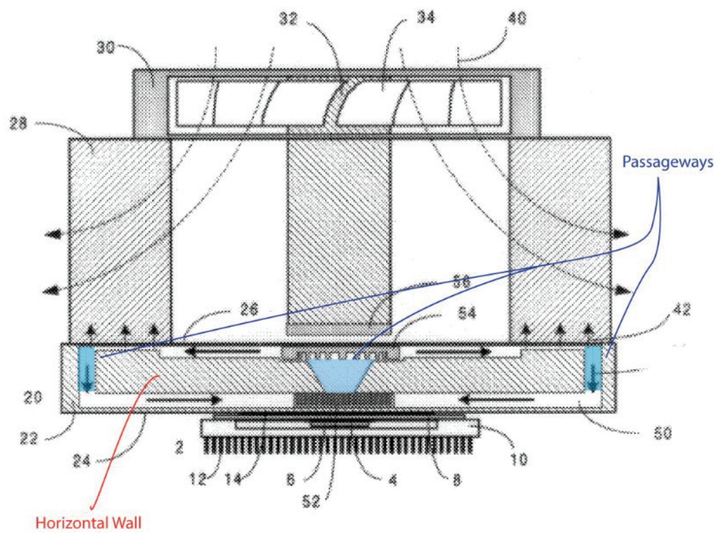




(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

485. To the extent this was not made obvious by Shin alone or with the experience, education, and training of a POSA, it would have been obvious based on Batchelder. A POSA would have been motivated to include a second passage at the perimeter of the lower chamber because it would provide an unobtrusive way to remove the cooling fluid from

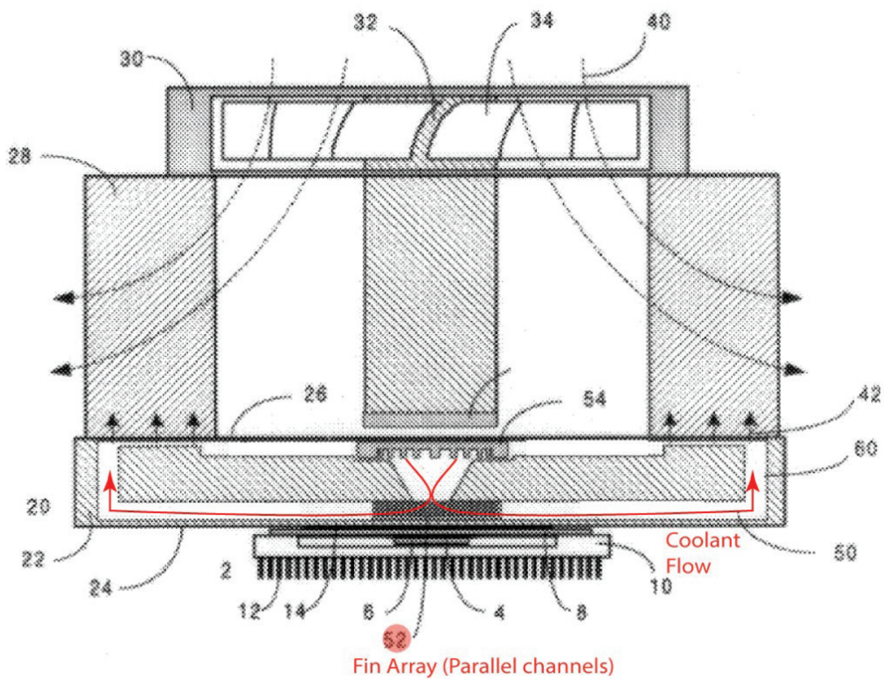
the heated region so that the cooling fluid can be routed away and the heat contained within the cooling fluid can be transferred to the ambient environment.



Batchelder, Figure 2

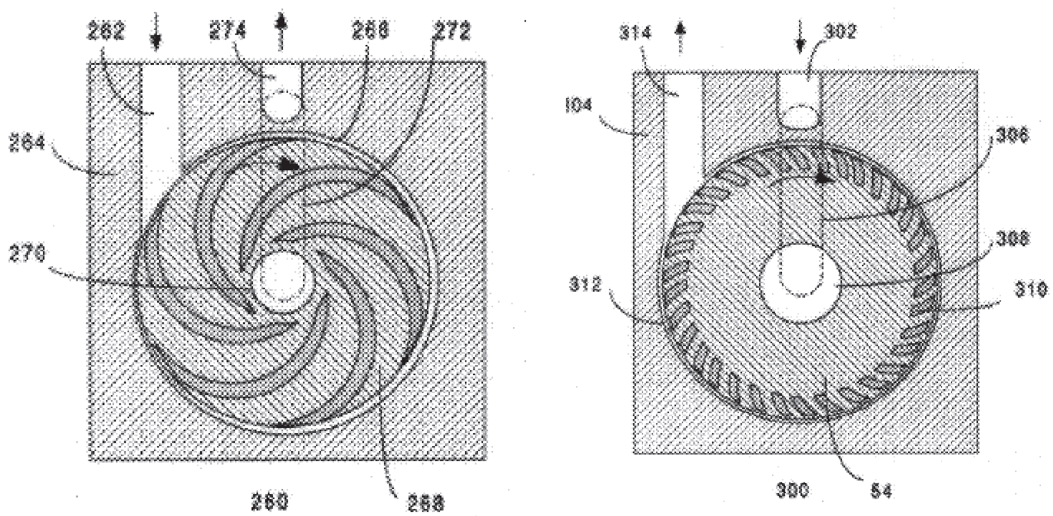
1(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage

486. Shin, in view of Batchelder discloses this claim element. Batchelder teaches a lower chamber with a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber, where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

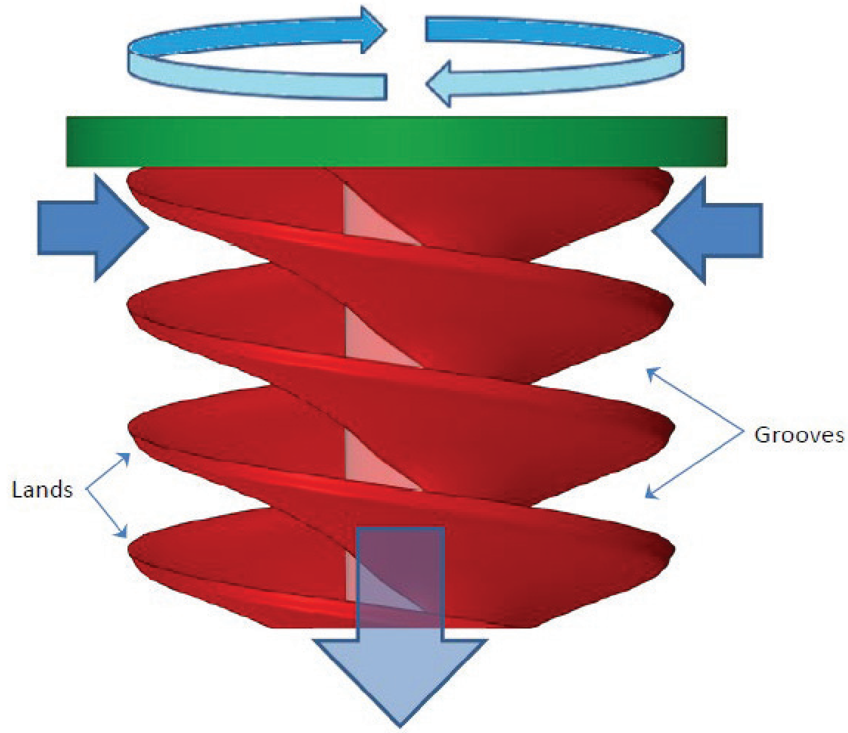


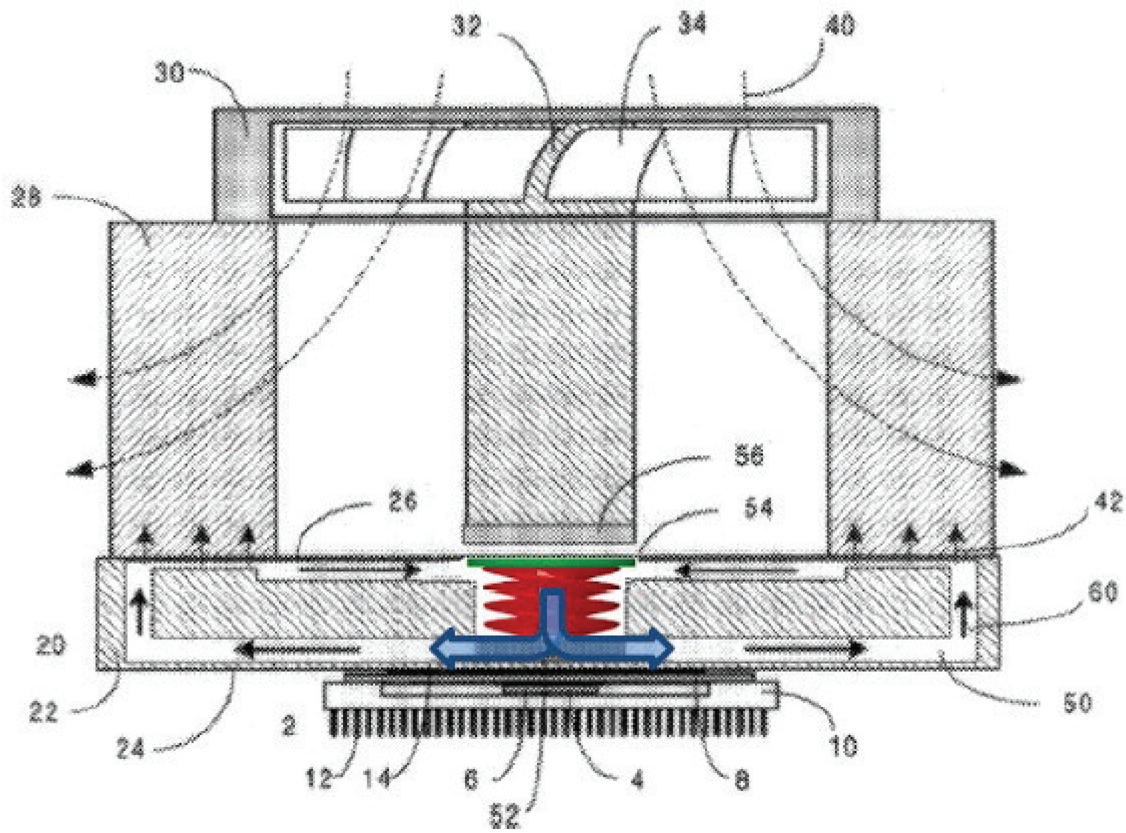
Batchelder, Figure 2

487. Batchelder teaches the use of pumps that provide flow in different directions, as shown by the following from Figure 9. With the pump on the left, the flow would be in the direction indicated by red arrows in the preceding paragraph. (Batchelder, 8:16-27)

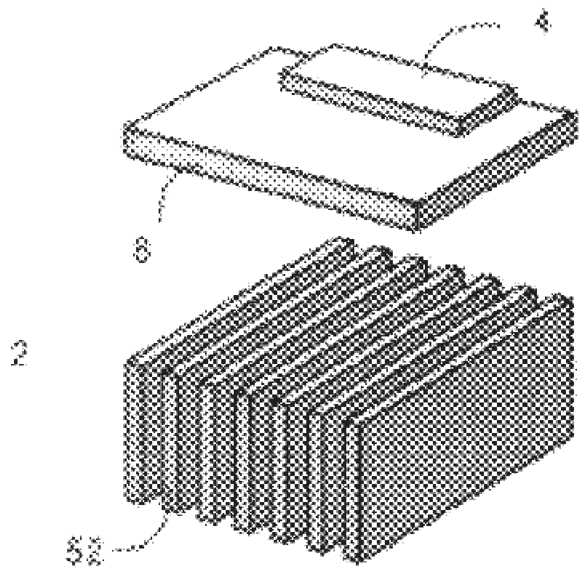


From Batchelder, Figure 9


Grooves
Lands

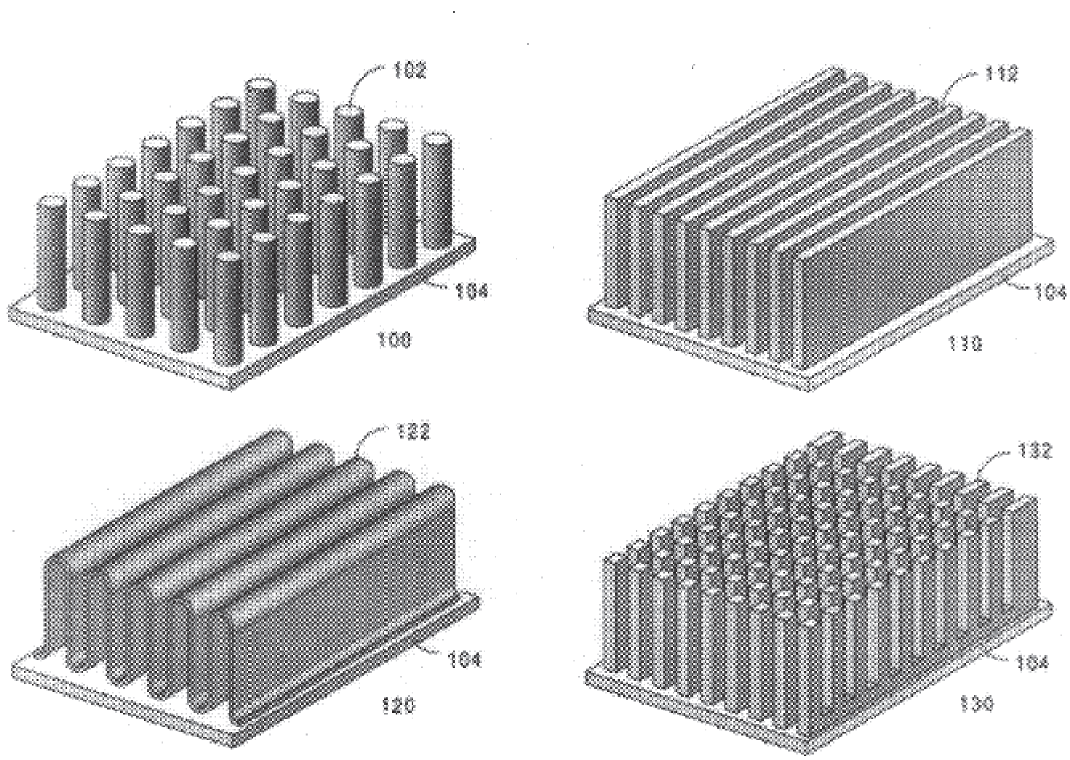

32
34
40
30
28
56
26
54
42
60
20
50
22
2
10
24
12
14
6
4
8
52

14. Using a viscosity pump would result in a system as shown above. Further, as can be seen below, Batchelder discloses parallel channels formed in the lower chamber that direct fluid. The parallel channels are created by the fin array (52) that Batchelder discloses.



From Batchelder Figure 4

488. Batchelder discloses or teaches other versions of fin arrays (110 and 120 below) that result in the claimed parallel channels, as shown here.



From Batchelder, Figure 6

489. Additionally, this would have been obvious in view of the education, experience, and training of a POSA. A POSA would have expected to use parallel channel fins to cool the computer chip, as demonstrated by the images from Batchelder. In fact, these types of fin arrays are the most common types available. I have taught about the use of parallel channel fin arrays for decades; it is a standard topic in both undergraduate and graduate courses in heat transfer. A POSA would have been motivated to incorporate a lower chamber with a plurality of channels configured to split the flow of cooling liquid and direct the liquid from the central region toward the perimeter of the lower chamber where the fluid is collected. Such a flow design promotes effective cooling at the heated location and reduces pressure losses in the fluid. This improves the hydraulic performance of the pump and thus the efficiency of the cooling system. The use of

channels increases the heat transfer surface area and thereby reduces the temperature of the heat-generating component.

1(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

490. Shin discloses or teaches this limitation, it has a heat exchanging interface that is attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid.

[Means for solving the problem] To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink.

Shin [0007]

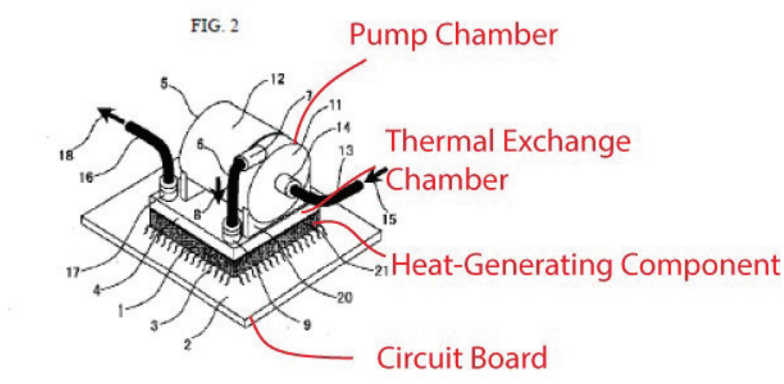
[0012]
[Embodiments of the invention] A first embodiment example of the present invention will be described using FIG. 1. The heat generating element 1, which includes an electronic circuit component such as an LSI chip, is installed on a wiring board 2 in electrical contact via wiring pins 3, solder balls or the like. The heat generating element 1 is, for example, a computer CPU, image processing LSI chip, FET power amplifier, etc. On the heat generating element 1, a liquid cooled heat sink 4 for liquid cooling of the heat generating element 1 is installed in thermal contact therewith across a thermally conductive compound 21, thermally conductive grease, thermally conductive sheet, or the like. Furthermore, a pump 5 which pressurizes and circulates liquid coolant is installed on the top part of the liquid cooled heat sink 4.

Shin [0012]

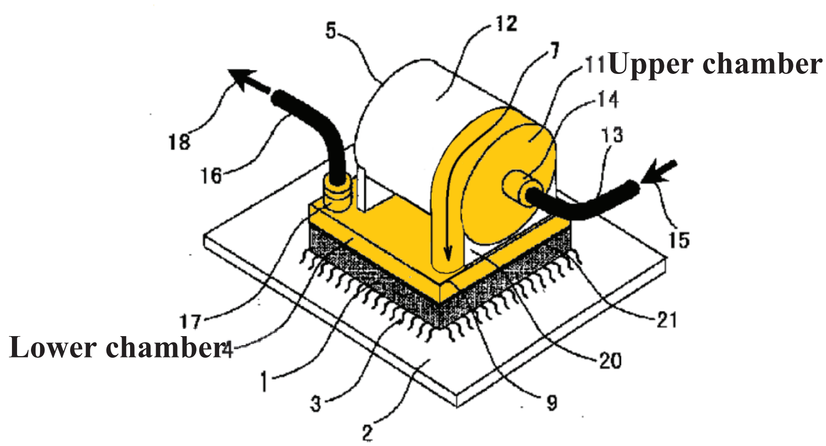
[Claim 1] A cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on said wiring board, a liquid cooled heat sink installed on said heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, characterized in that said pump is installed on the top part of said liquid cooled heat sink.

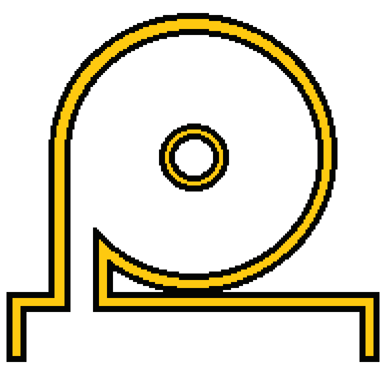
Shin, Claim 1

491. The heat exchange surface of Shin is illustrated in the following figures (bottom surface of the thermal exchange chamber). The heat exchanging interface is in thermal contact with the heat generating electrical components, it also forms the lower boundary wall of the lower chamber.

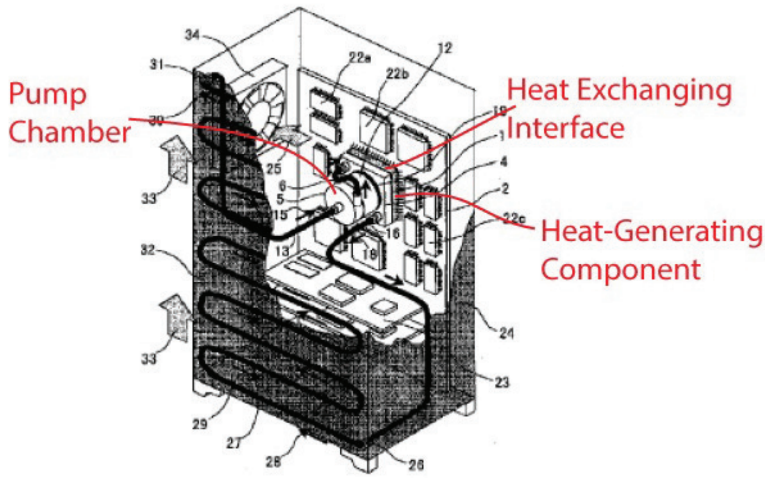


Shin, Figure 2 (with the upper (thermal exchange) chamber modified as below)





(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)



Shin, Figure 3

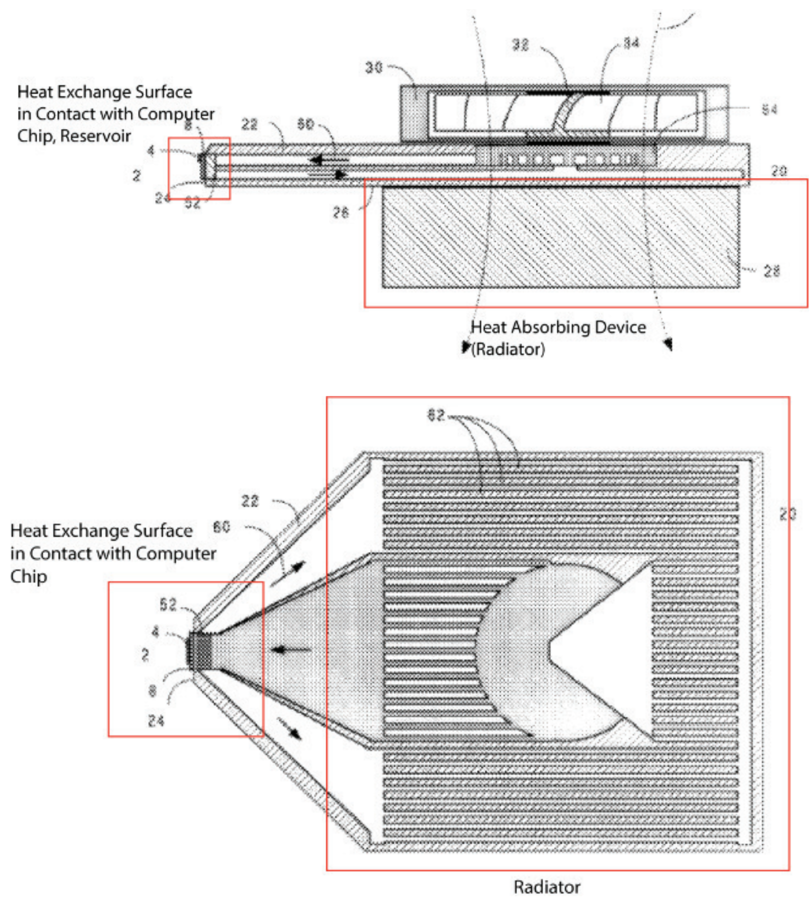
492. While this limitation is obvious based on Shin alone, it is also obvious based on Shin, in view of the experience, education, and training of a POSA. First, a POSA working on thermal management of electronics would have known about the importance of thermal contact. Also, it is routine to use a surface of a reservoir to provide thermal contact, because it reduces the thermal resistance between the heat-generating component and the fluid. This is a very common issue and is a topic of undergraduate and graduate courses on heat transfer. I have taught about the importance of thermal contact for decades. A POSA would have been motivated to attach a heat exchanging interface to the reservoir to form a boundary wall of the lower chamber and to enable thermal contact between the processing unit and the cooling liquid. Thermal contact reduces the thermal resistance and thereby lowers the temperature of the heat generating component.

493. This limitation is further obvious in view of Batchelder. Batchelder discusses its thermal contact between a heat-exchanging interface and a computer processor/heat-generating component.

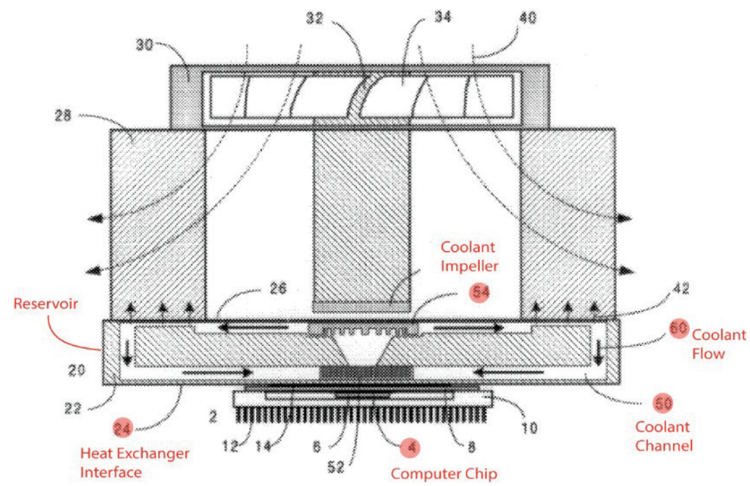
> FIG. 7 shows an assembly of a heat sink containing an active spreader plate. A heat source (2) is attached to the bottom sheet (202) of the active spreader plate assembly through a compliant insulating layer (14). If the heat source

Batchelder, Col. 7 lines 23-26

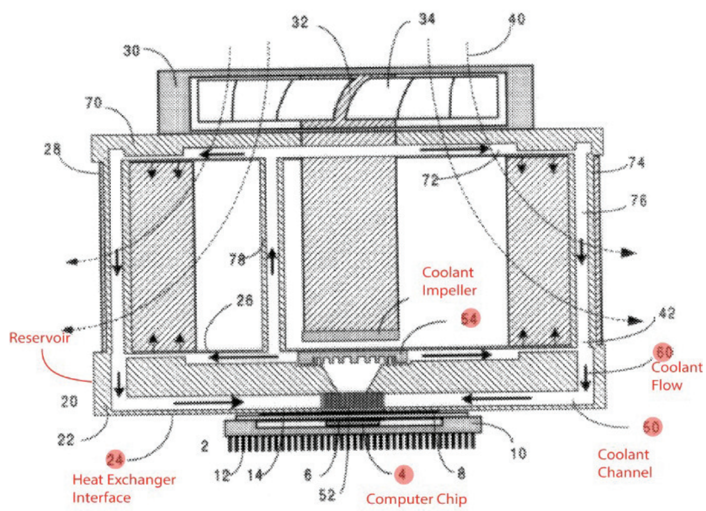
494. Batchelder embodiments also disclose the limitation, as shown here:



Batchelder, Figure 4



Batchelder, Figure 2



Batchelder, Figure 5

1(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

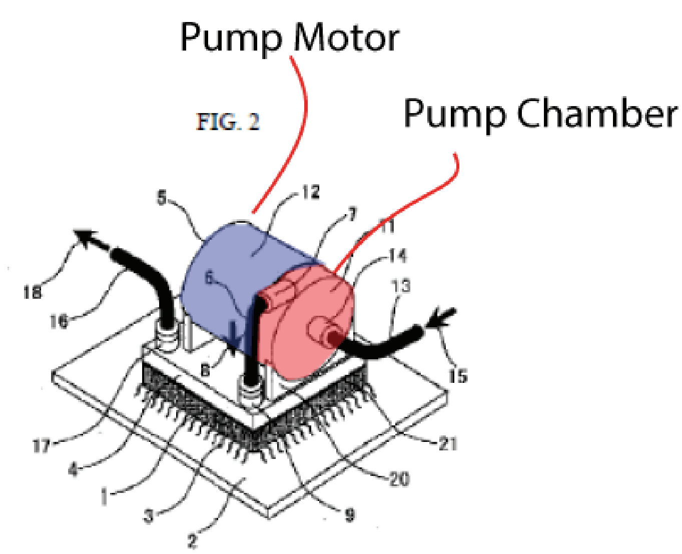
495. Shin discloses a pump having a motor and an impeller with the impeller positioned within the upper chamber of the reservoir. The upper chamber of the reservoir of Shin is indicated below.

[0018] The pump 5 comprises an impeller case 11 and motor 12. In the present embodiment example, the pump 5 illustrates an example of a centrifugal type pump which pressurizes liquid coolant by rotating an impeller arranged inside the impeller case 11, but a volumetric type pump

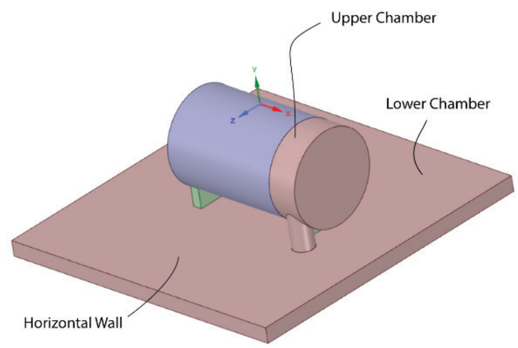
Shin [0018]

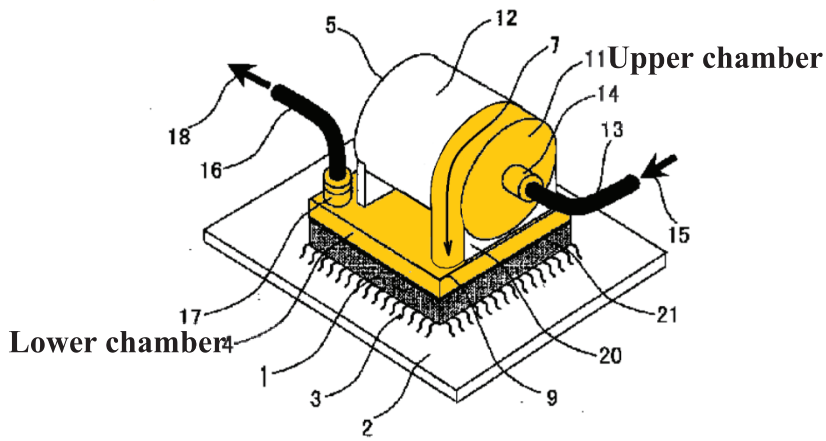
[0019] The motor 12 is a DC motor driven by a direct current power supply. Using a DC motor allows the motor speed to be easily changed by changing the DC voltage, thus enabling control of cooling power. Moreover, making the motor into a DC brushless motor makes it possible to implement a pump of low noise and long service life.

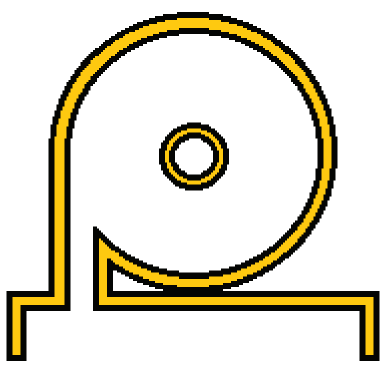
Shin [0019]



Shin, Figure 2 (with the upper and lower chambers modified as follows)







(Schematic of cross-sectional view of the single-receptacle "reservoir" of modified Shin)

496. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious based on the experience, education, and training of a POSA. A POSA would have known that an impeller is used to propel the liquid coolant flow. The impeller would

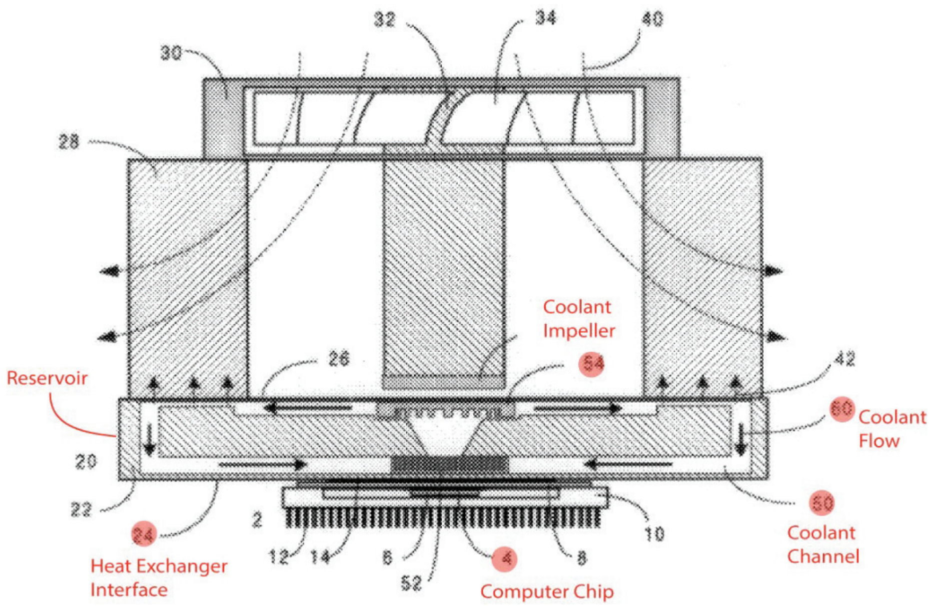
have to be confined within a chamber to function. A POSA working on thermal management of electronics or liquid pumps would already be familiar with the positioning of pump impellers within chambers. In fact, liquid pumps are purchased with impellers so positioned. Furthermore, I have on numerous occasions used such pumps and instructed students on their use. A POSA would have been motivated to use a pump with a motor and an impeller with the impeller positioned in the upper chamber of the reservoir. This design makes the flow hydraulically efficient and thus improves performances. In addition, this design reduces the size of the cooling system and also reduces the number of tubes and fluid connections, and thus lowers the risk of leaks.

497. To the extent it was not disclosed or taught based on Shin, it would have been obvious in view of Batchelder. The impeller of Batchelder is driven by motor 32, which is external to the reservoir.

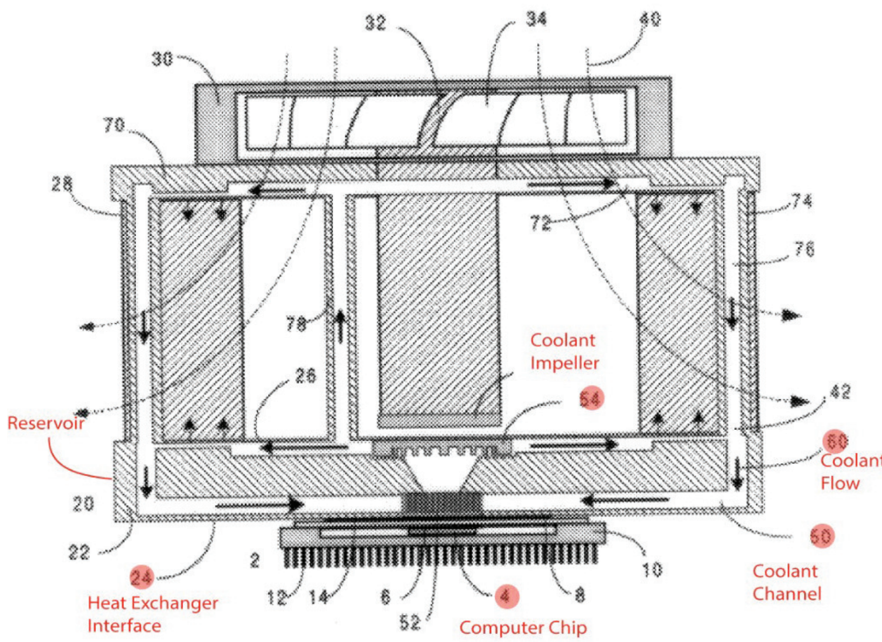
[57] **ABSTRACT**

An apparatus to transfer heat from a heat source to a heat absorber, the apparatus consisting of an active thermal spreader plate with internal flow channels, a recirculating heat transfer fluid, and a means to impel the heat transfer fluid using an external moving magnetic field. In the most preferred embodiment a centripetal pump impeller is trapped inside the active thermal spreader plate, and the impeller is motivated to rotate due to eddy currents generated by the external moving magnetic fields.

Batchelder, Abstract



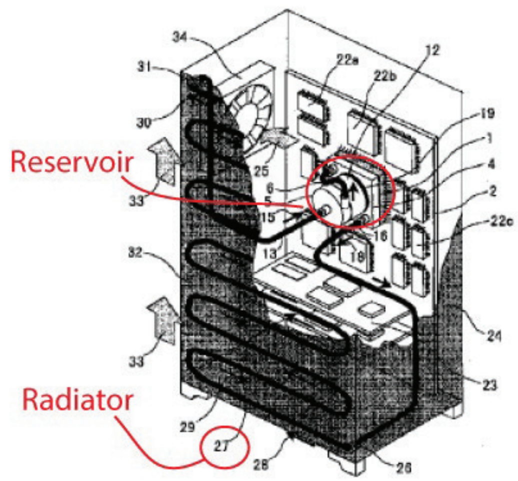
Batchelder, Figure 2



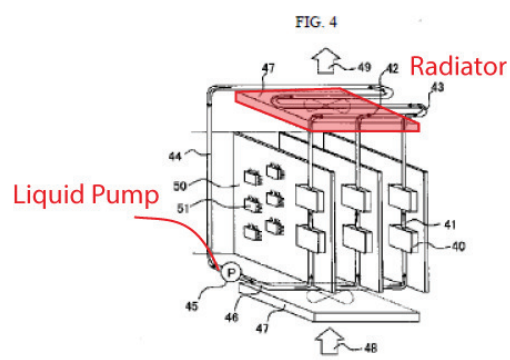
Batchelder, Figure 5

1(h) a radiator spaced apart from and fluidly coupled to the reservoir

498. Shin discloses a radiator spaced apart and fluidly coupled to the reservoir, as shown below. The fluid coupling is indicated by the black arrows which represent the direction of coolant flow.

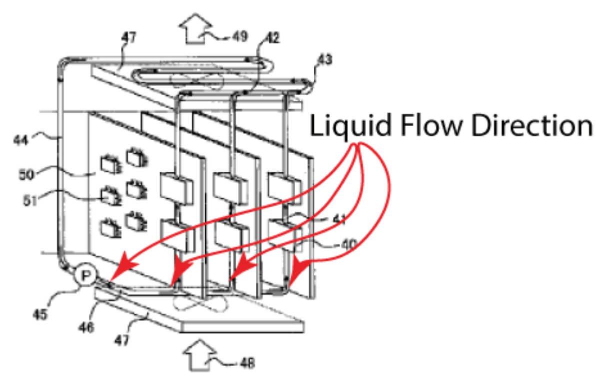


Shin, Figure 3



Shin, Figure 4

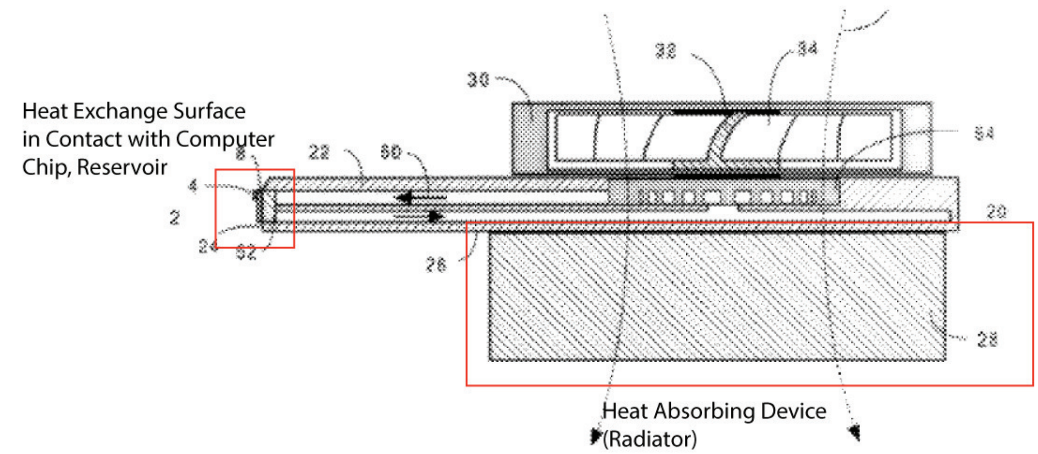
FIG. 4

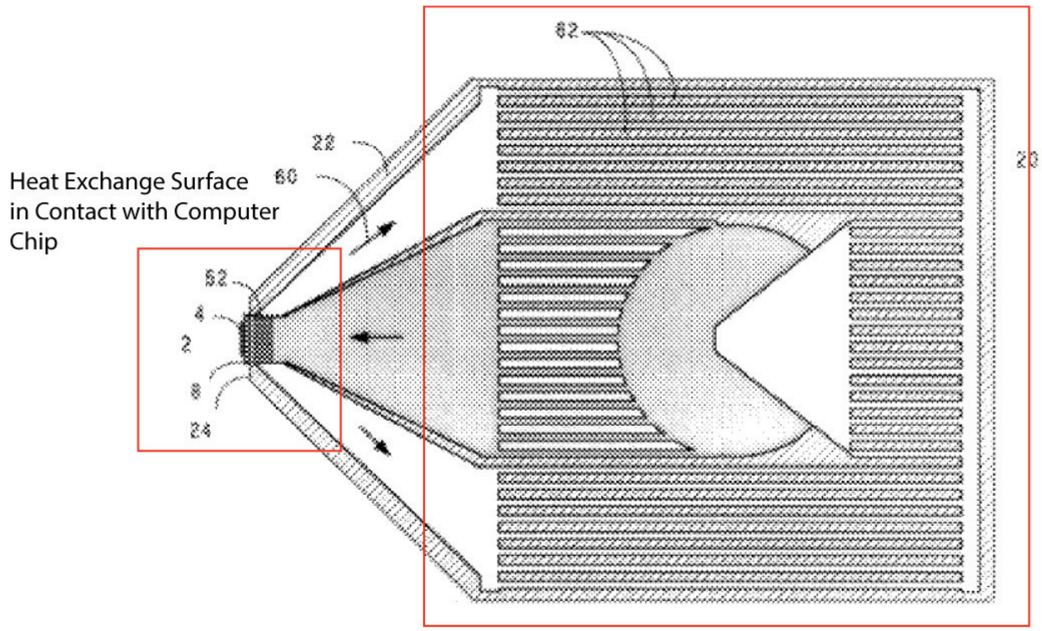


Shin, Figure 4, showing flow of liquid coolant

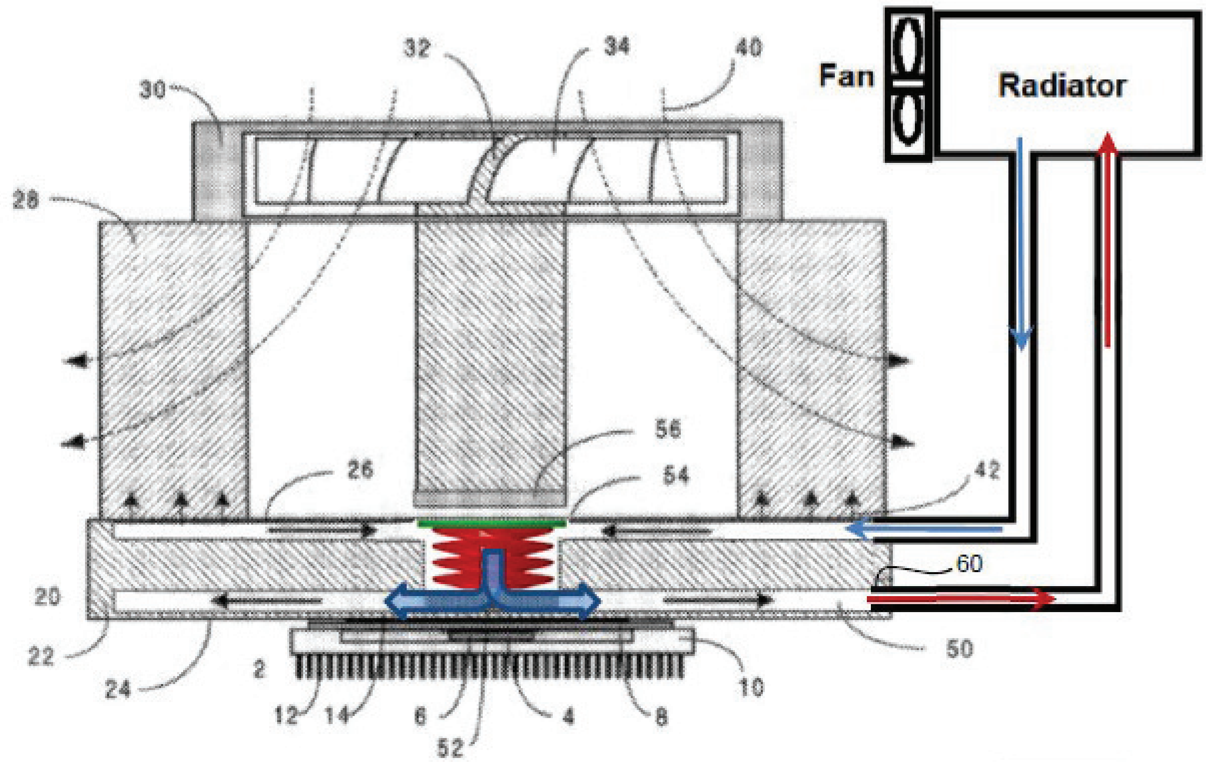
499. To the extent this was not disclosed or taught by Shin alone, it would have been obvious in view of the knowledge of a POSA. In fact, radiators are routinely used to remove heat from coolants after they have absorbed thermal energy from heat-generating components, such as CPUs. I have used such radiators myself and I have seen, analyzed, and inspected numerous devices with such radiators. I have also taught undergraduate and graduate students (for two decades) on their use. A POSA would have been motivated to implement a radiator that is spaced apart and fluidly coupled to the reservoir because this allows heat to be transferred from the vicinity of the heated region to the ambient environment, thus improving the performance of the system and lowering the temperature of the heat-generating component.

500. To the extent this was not disclosed or taught based on Shin, in view of the knowledge of a POSA, it would have been obvious based on Batchelder. Batchelder teaches a radiator that is separated from, but fluidly connected to, the reservoir. With the use of the viscosity pump in Batchelder as discussed above, the combined Shin plus Batchelder system is shown in the third diagram below, as would have been understood by a POSA.





Batchelder, Figure 4



Claim 6 preamble: A cooling system for a computer system processing unit, comprising

501. To the extent this preamble is limiting, it was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

502. This claim limitation was disclosed or taught by Shin (as modified) either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

503. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

504. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(d) a second passage positioned at a perimeter of the lower chamber;

505. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(e) wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber;

506. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

507. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

508. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

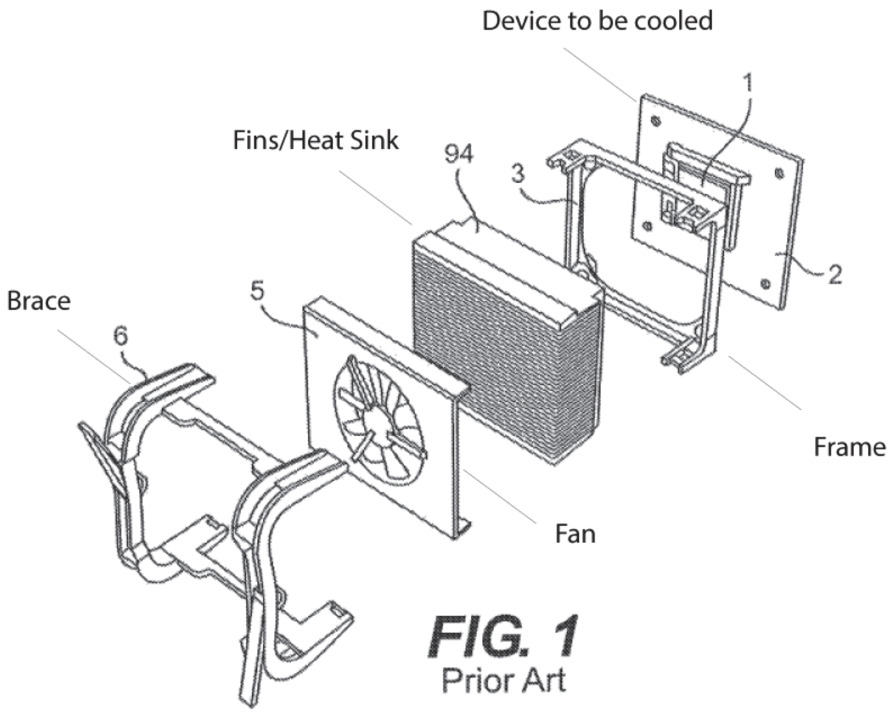
6(h) a radiator spaced apart from and fluidly coupled to the reservoir;

509. This claim limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

510. This claim is obvious based on Shin, in view of the experience, education, and training of a POSA. Frames are commonly used to fasten a reservoir to a board on a computer system processing unit. As I have already discussed, Shin teaches the creation of thermal contact between the reservoir and the CPU. Thermal contact is important to ensure heat transfer from the CPU into the coolant. Reducing thermal resistance by use of a frame is commonly performed, I have on many occasions worked with, designed, or evaluated frames that are used in this way. Typically frames have holes that are used to facilitate fasteners (like screws) that hold the cooling device in contact with the CPU. In fact, as a POSA, I would expect a frame to be configured to fasten a reservoir to a board with four holes that correspond to four holes in the board. which a CPU is configured. This promotes thermal contact and thus improved performance. It also reduces the likelihood that the cooling system will become dislodged from the heat-generating component.

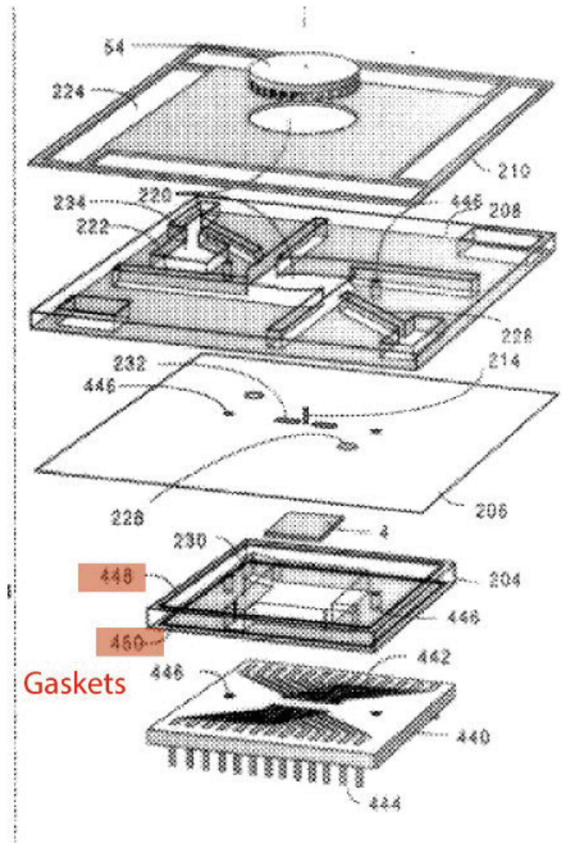
511. As evidence by the ubiquitous nature of such frames, I have included prior art Figure 1, from the ’601 patent. There, a frame (3) is identified which has four holes in its corners that correspond to the circuit board (2).



’601 patent, Figure 1

6(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

512. Gaskets are ubiquitous in liquid pumps and in thermal management of electronic systems. For instance, gaskets are expressly called out in Batchelder, as shown here.



Batchelder, Figure 13

513. To the extent this was not disclosed or taught in view of Batchelder, it would have been obvious to use a gasket, based on the experience, education, and training of a POSA. A POSA would have known that gaskets are used at interfaces between fluid-conveying structures to reduce or eliminate leaks at those interfaces. Gaskets, such as O-rings, are commonly used in even the most rudimentary engineering systems. A POSA would have been motivated to use a gasket to create a seal between the reservoir and the heat generating component to reduce the likelihood of leaks, result in vibration resistance, and to aid in assembly.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

514. This claim is obvious based on Shin alone, or based on Shin in view of the knowledge of a POSA and/or further based on Batchelder. In fact, in the following passage, Shin expressly discusses controlling the pump speed by controlling the voltage provided to the pump.

[0019] The motor 12 is a DC motor driven by a direct current power supply. Using a DC motor allows the motor speed to be easily changed by changing the DC voltage, thus enabling control of cooling power. Moreover, making the motor into a DC brushless motor makes it possible to implement a pump of low noise and long service life.

Shin, [0019]

515. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious in view of the experience, education, and training of a POSA. Voltage controlled pumps are commonly and ubiquitously employed with liquid pumps; I have personally used them numerous times throughout my career. A POSA would have been motivated to use a control system with a cooling system so that the cooling system can be modified based on the thermal and pressure requirements. In particular, a control system allows the cooler to operate more efficiently, reducing the temperature of the heat generating component as well as noise and power.

516. To the extent this was not disclosed or taught based on Shin in view of the knowledge of a POSA, it would have been obvious based on Batchelder which discloses the control of a pump here:

13

$$\omega_{impeller} = \frac{k_1 \sigma_{impeller}^2 \omega_{fan} - k_2 / 2}{k_1 \sigma_{impeller}^2 + k_3}$$

The impeller speed is always less than the fan speed, and the impeller speed is increased with an increase in the impeller's electrical conductivity. The coupling between the external magnetic field and the impeller (k_1) can be mechanically modified by adjusting the gap between the impeller and the rotating permanent magnet (**56**).

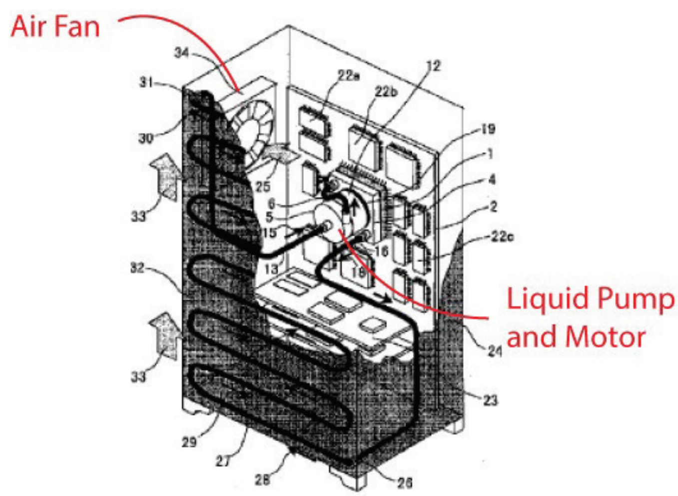
Batchelder, Column 13, lines 1-11

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

517. This claim is obvious based on Shin alone, or based on Shin in view of the knowledge of a POSA and/or further based on Batchelder. The desire to reduce noise generating by pumps is expressly discussed in Shin, for example:

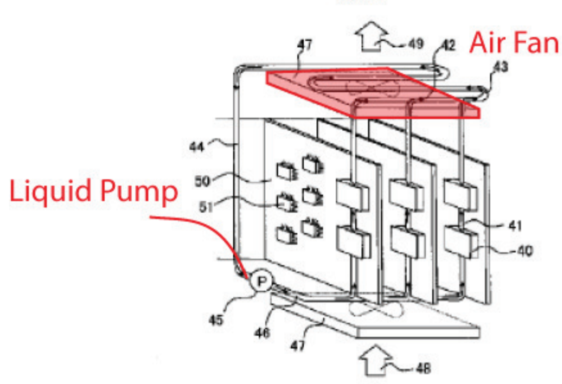
[0019] The motor 12 is a DC motor driven by a direct current power supply. Using a DC motor allows the motor speed to be easily changed by changing the DC voltage, thus enabling control of cooling power. Moreover, making the motor into a DC brushless motor makes it possible to implement a pump of low noise and long service life.

Shin, [0019]



Shin, Figure 3

FIG. 4



Shin, Figure 4

518. A POSA would have known that the fans illustrated in the above images are configured to be controlled. Air fans also generate noise that can be bothersome to users. In fact, air fans are typically the loudest component of a computer system. POSAs routinely work to reduce the sounds by either audibly insulating the fans or more commonly, reducing the fan speed.

519. I have personally worked with air fans such as those disclosed in Shin and shown below. Insofar as the fans are connected to a DC power supply, they are configured to have an adjustable rotational speed.

520. To the extent this was not disclosed or taught based on Shin alone, it would have been obvious in view of the experience, education, and training of a POSA. Voltage controlled pumps are commonly and ubiquitously employed with liquid pumps; I have personally used them numerous times throughout my career. In fact, I have been employed by companies to reduce the noise of pump/fan operation by reducing the rotating rate of the fan and/or the pump. A POSA would have been motivated to use a control system with a cooling system so that the cooling system can be modified based on the thermal and pressure requirements. In particular, a control system that adjusts the rotational speed of the fan allows the cooler to operate more efficiently, reducing the temperature of the heat generating component as well as noise and power.

Claim 12 preamble: A cooling system for a computer system processing unit, comprising:

521. To the extent this preamble is limiting, it was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

522. This limitation was disclosed or taught by Shin (as modified) either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

523. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

524. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(d) a second passage positioned at a perimeter of the lower chamber;

525. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

526. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

527. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

528. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(h) a radiator spaced apart from and fluidly coupled to the reservoir;

529. This limitation was disclosed or taught by Shin (as modified) either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

12(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

530. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 6. I adopt that prior discussion here.

12(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

531. This limitation was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 6. I adopt that prior discussion here.

B. Ground 2 – Shin in View of Batchelder and Further in View of Nakano

532. It is my opinion that Shin, in view of Batchelder, further in view of Nakano, renders claim 11 of the ’601 patent obvious, for the reasons I will now discuss. Claim 11 depends from claim 7, which depends from claim 6, which is rendered obvious by Shin in view of Batchelder as discussed above, of which I adopt the prior analysis here.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

533. To the extent this was not disclosed or taught by Shin in view of Batchelder, it would have been obvious further in view of Nakano. Nakano expressly discusses a control system to modulate the cooling system by adjusting the rotational speed of a fan. A POSA would have been motivated to use a control system with a cooling system so that the cooling system can be modified based on the thermal and pressure requirements. In particular, a control system allows the cooler to operate more efficiently, reducing the temperature of the heat generating component as well as noise and power.

It is accordingly an objective of the present invention to provide a highly reliable semiconductor cooling device that is low in noise level and can conduct an appropriate control by changing the amount of circulation of refrigerant depending on the amount of heat generated by a semiconductor element.

In accomplishing the above and other objectives, the semiconductor cooling device according to the present invention includes a cold plate for cooling a semiconductor element, a condenser, and an inverter-controlled refrigerant pump, all of which are fluid connected in series with each other to define a refrigerating cycle. The semiconductor cooling device also includes a fan for cooling the condenser, a temperature detector disposed in proximity to the semiconductor element, and a controller for controlling the refrigerant pump and the fan. The controller controls the number of revolutions of the refrigerant pump and that of the fan depending on a value measured by the temperature detector. The temperature detector may be accommodated in the semiconductor element.

When the amount of heat emitted from the semiconductor element is less than a predetermined level, the controller reduces the number of revolutions of the fan before that of the refrigerant pump.

When the value measured by the temperature detector increases more than a predetermined value within a predetermined period of time, the controller maximizes the number of revolutions of the fan and thereafter increases the number of revolutions of the refrigerant pump step by step while comparing the value measured by the temperature detector with a value set in the controller. Furthermore, when the number of revolutions of the refrigerant pump has

Nakano, Column 1 lines 36-67

2

reached a maximum value, if the value measured by the temperature detector does not become less than the set value, the controller outputs an alarm signal.

Alternatively, the controller watches a signal indicative of a current value of the refrigerant pump, and if such current value becomes greater than a value set in the controller, the controller outputs an alarm signal.

Again alternatively, the controller watches an operating time of the refrigerant pump, and if a total operating time of the refrigerant pump has reached a service life set in the controller, the controller outputs an alarm signal.

Nakano, Column 2, lines 1-12

In this embodiment, the cold plate **1** is provided with a temperature sensor **6** mounted thereon in proximity to the semiconductor element **5**, and the temperature sensor **6** is electrically connected to a controller **9**. The refrigerant pump **3** is electrically connected to an inverter controller **7**, while the fan **4** is electrically connected to a power controller **8**. Both the inverter controller **7** and the power controller **8** are electrically connected to the controller **9**.

The controller **9** appropriately controls the number of revolutions of the refrigerant pump **3** and that of the fan **4** based on a value measured by the temperature sensor **6**. The

Nakano, Column 2, lines 57-67

3

controller **9** is designed so as to preferentially reduce, when the amount of heat emitted from the semiconductor element **5** is less than a predetermined level, the number of revolutions of the fan **4** before that of the refrigerant pump **3**, making it possible to provide a cooling device that is low in noise level.

When the value measured by the temperature sensor **6** increases more than a predetermined value within a predetermined period of time, the controller **9** first maximizes the number of revolutions of the fan **4** and then increases the number of revolutions of the refrigerant pump **3** step by step while comparing the measured value by the temperature sensor **6** with a value set in the controller **9**. When the number of revolutions of the refrigerant pump **3** has reached a maximum value, if the measured value by the temperature sensor **6** does not become less than the set value, the controller **9** outputs an alarm signal to a computer that is electrically connected to the semiconductor element **5**, making it possible to enhance the reliability of the cooling device.

Although the above-described embodiment employs the temperature sensor **6**, temperature measurement may be carried out by the semiconductor element **5** itself. In this case, a signal from the semiconductor element **5** is inputted into the controller **9**.

Nakano, Column 3, lines 1-25

FIG. **3** depicts a refrigerating cycle of a semiconductor cooling device according to a second embodiment of the present invention.

As shown in FIG. **3**, the semiconductor element **5** is provided with a temperature detector **6** accommodated therein. A signal indicative of the current value of the refrigerant pump **3** is outputted from the inverter controller **7** to the controller **9**, which in turn watches the signal and outputs, if such current value becomes greater than a value set therein, an alarm signal to a computer that is electrically connected to the semiconductor element **5**. Accordingly, the refrigerant pump **3** can be replaced with a new one before its service life ends, enhancing the reliability of the cooling device.

Alternatively, the controller **9** may be designed so as to watch the operating time of the refrigerant pump **3**. In this case, if the total operating time of the refrigerant pump **3** has reached a service life set in the controller **9**, the controller **9** outputs an alarm signal to the computer. Accordingly, the refrigerant pump **3** can be replaced with a new one when its service life ends, enhancing the reliability of the cooling device.

Nakano, Column 3, lines 27-48

1. A semiconductor cooling device comprising:

a cold plate for cooling a semiconductor element;

a condenser;

an inverter-controlled refrigerant pump, said cold plate, condenser and refrigerant pump being fluid connected in series with each other to define a refrigerating cycle;

a fan for cooling said condenser;

a temperature detector disposed in proximity to said semiconductor element; and

a controller for controlling said refrigerant pump and said fan;

wherein said controller controls the number of revolutions of said refrigerant pump and that of said fan depending on a value measured by said temperature detector.

Nakano, Claim 1

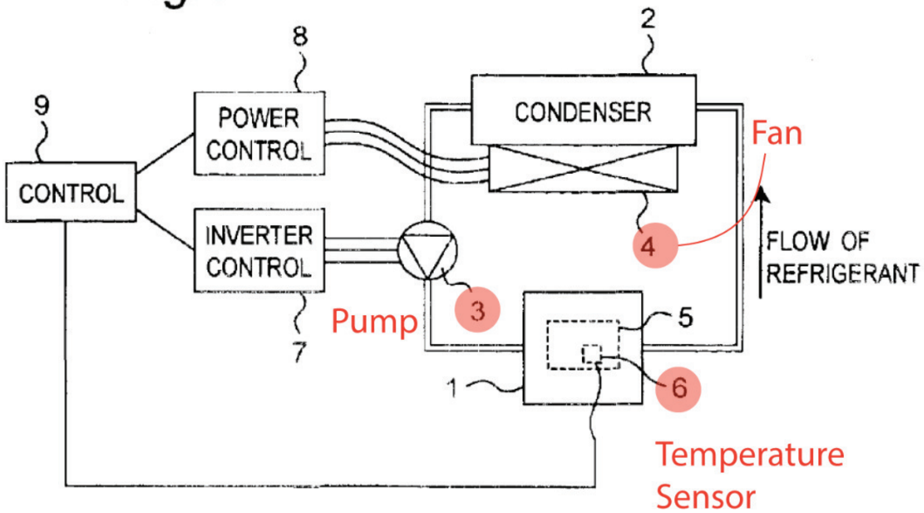
4. The semiconductor cooling device according to claim 1, wherein when the value measured by said temperature detector increases more than a predetermined value within a predetermined period of time, said controller maximizes the number of revolutions of said fan and thereafter increases the number of revolutions of said refrigerant pump step by step while comparing the value measured by said temperature detector with a value set in said controller, and wherein when the number of revolutions of said refrigerant pump has reached a maximum value, if the value measured by said temperature detector does not become less than the set value, said controller outputs an alarm signal.

5. The semiconductor cooling device according to claim 1, wherein said controller watches a signal indicative of a current value of said refrigerant pump, and if such current value becomes greater than a value set in said controller, said controller outputs an alarm signal.

6. The semiconductor cooling device according to claim 1, wherein said controller watches an operating time of said refrigerant pump, and if a total operating time of said refrigerant pump has reached a service life set in said controller, said controller outputs an alarm signal.

Nakano Claims 4-6

Fig.3



Nakano, Figure 3

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

534. This claim was disclosed or taught by Shin either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

535. To the extent this was not disclosed or taught with the above combination, it would have been obvious in view of Nakano. Nakano expressly discusses a control system to modulate the cooling system by adjusting the rotational speed of a fan as discussed above, and I adopt that prior discussion here. A POSA would have been motivated to use a control system with a cooling system so that the cooling system can be modified based on the thermal and pressure requirements. In particular, a control system that adjusts the rotational speed of the fan allows the cooler to operate more efficiently, reducing the temperature of the heat generating component as well as noise and power.

C. Ground 3 – Batchelder in View of Shin

536. It is my opinion that Batchelder, in view of Shin, renders claims 1, 6, 11, and 12 of the ’601 patent obvious, for reasons that I will now discuss.

Claim 1 preamble: A cooling system for a computer system processing unit, comprising;

537. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this preamble, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(a) A reservoir configured to circulate a cooling liquid therethrough the reservoir including:

538. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls

539. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber

540. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(d) a second passage positioned at a perimeter of the lower chamber;

541. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage

542. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

543. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

544. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

1(h) a radiator spaced apart from and fluidly coupled to the reservoir

545. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

Claim 6 preamble: A cooling system for a computer system processing unit, comprising

546. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this preamble, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

547. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

548. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

549. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(d) a second passage positioned at a perimeter of the lower chamber;

550. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(e) wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber;

551. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

552. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

553. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(h) a radiator spaced apart from and fluidly coupled to the reservoir;

554. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

555. Batchelder in view of a POSA and Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

6(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

556. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

557. Batchelder in view of a POSA and Shin, discloses this claim, as I have already demonstrated in Ground 1. I adopt that analysis here.

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

558. Batchelder in view of a POSA and Shin, discloses this claim, as I have already demonstrated in Ground 1. I adopt that analysis here.

Claim 12 preamble: A cooling system for a computer system processing unit, comprising:

559. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses this preamble, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

560. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

561. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

562. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(d) a second passage positioned at a perimeter of the lower chamber;

563. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

564. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

565. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

566. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(h) a radiator spaced apart from and fluidly coupled to the reservoir;

567. Batchelder, either alone, or in view of a POSA and/or in view of Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

568. Batchelder in view of a POSA and Shin, discloses or teaches this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

12(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

569. Batchelder, either alone, or in view of a POSA and/or in view of Shin, disclose this limitation, as I have already demonstrated in Ground 1. I adopt that analysis here.

D. Ground 4 – Batchelder in View of Shin and Further in View of Nakano

570. It is my opinion that Batchelder, in view of the knowledge of a POSA and/or in view of Shin, further in view of Nakano, renders claim 11 of the ’601 patent obvious, for reasons that I will now discuss. Claim 11 depends from claim 7, which depends from claim 6, which is rendered obvious by Shin in view of Batchelder as discussed above, of which I adopt the prior analysis here.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

571. Batchelder, either alone, or in view of the knowledge of a POSA and/or in view of Shin, further in view of Nakano, discloses this claim, as I have already demonstrated in Ground 1. I adopt that analysis here.

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

572. Batchelder, either alone, or in view of the knowledge of a POSA and/or in view of Shin, further in view of Nakano, discloses this claim, as I have already demonstrated in Ground 1. I adopt that analysis here.

E. Ground 5 – Yu in View of Batchelder

573. It is my opinion that Yu, in view of the experience, education, and training of a POSA, and in view of Batchelder, further in view of Nakano, renders claims 1, 6, and 12 of the '601 patent invalid.

Claim 1 preamble: A cooling system for a computer system processing unit, comprising;

574. While I do not understand that preamble to this claim to be limiting, if it does limit, then Yu discloses the preamble.

575. For further example, Yu discusses the use of liquid cooling systems for electronic components positioned on the motherboard of a computer system.

Abstract

The invention discloses a liquid cooling radiator which comprises a base, a fan, a pump and a water circulation loop. The base has a reservoir inside. The reservoir has two ports and serves to store cooling water. The fan is arranged on the base and has a fan blade body driven by electricity to rotate. The pump is arranged oppositely to the fan blade body of the fan and is positioned inside the reservoir of the base. A magnetic connector unit is arranged between the fan blade body and the pump. The water circulation loop is connected with the two ports of the base. With the above arrangement, the invention has a water-cooling mechanism and forces the heat dissipation of heating electronic components such as CPU.

Yu, abstract

TECHNICAL FIELD

The present invention is related to a liquid cooling radiator, especially a water cooling apparatus which can be used to force the heat dissipation of heating electronic components such as CPU.

Yu, Technical Field

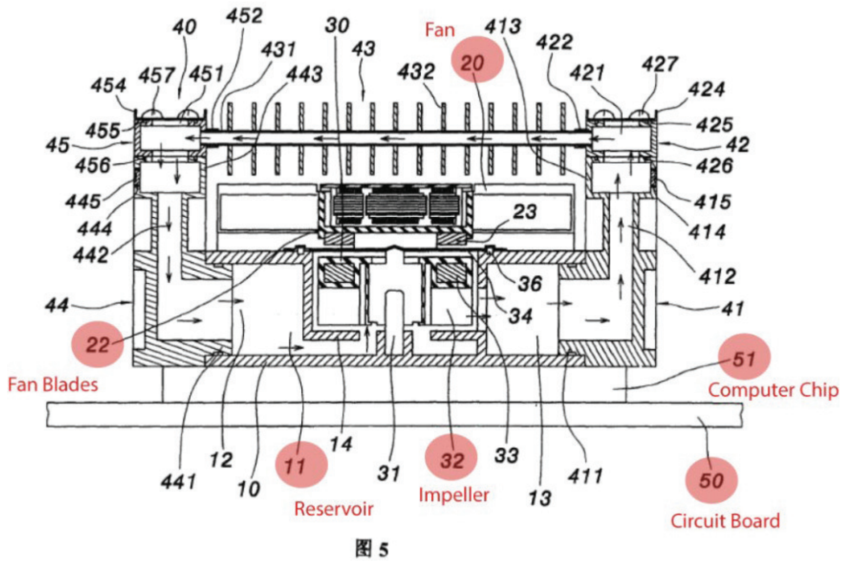
apparatus, which helps to force the cooling of the CPU through circulating cooling water and provides a more effective cooling method.

Yu, page 22

As shown in FIG. 5 and FIG. 6, the present invention could be attached to the CPU 51 on the motherboard 50 by its base 10, and could drive the pump 30 to rotate synchronously through the fan 20. The pump 30 could pump the cooling water which was inside the reservoir 11 through the base 10 out of the port 13. The water then passes through, sequentially, the first loop 41, the second loop 42, the third loop 43, the fourth loop 44 and the fifth loop 45 of the water circulation loop 40, and flows through the other port 12 of the base 10 into the reservoir 11, whereby the cooling water circulation can be established.

Therefore, the heat generated from the operation of the CPU 51 could be transferred to the base 10 and the water circulation loop 40. The material itself and the internal circulating water of the base 10 and the water circulation loop 40 could help with cooling. The circulating water could transfer the heat to the heat exchange cooling fin 432 to increase the cooling area, and can drive cold air with the fan 20 to flow through the base 10, water circulation 40 and out of heat exchange cooling fin 432 to achieve the cooling effect.

Yu, page 25



Yu, Figure 5

576. To the extent this preamble was not disclosed or taught by Yu, it would have been obvious to a POSA, based on her experience, education, and training, as I have already discussed with respect to Ground 1. I adopt that prior analysis here. A POSA would have been motivated to use a cooling system for a computer system processing unit in order to remove heat and maintain safe CPU temperatures.

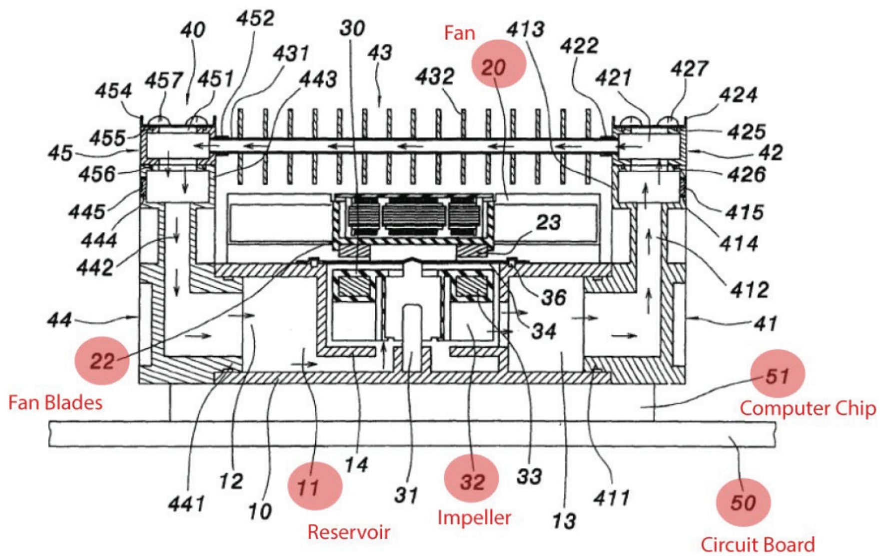
577. Furthermore, this preamble is also disclosed by Batchelder, as I have already discussed in connection with Ground 1. I adopt that prior analysis here.

1(a) A reservoir configured to circulate a cooling liquid therethrough the reservoir including:

578. Yu discloses the claimed reservoir, configured to circulate cooling liquid therethrough, as discussed above and further as shown here:

Please refer to FIG. 2, FIG.3 and FIG.4. This invention provides a liquid-cooling radiator apparatus, which includes a base 10, a fan 20, a pump 30, and a water circulation loop 40. The base 10 is made of metals of better heat dissipation rate, and has a reservoir 11. The reservoir 11 could store cooling water, and has a separator 14 inside, which could separate the interior of the reservoir 11 for suitable loops.

Yu, page 23



Yu, Figure 5

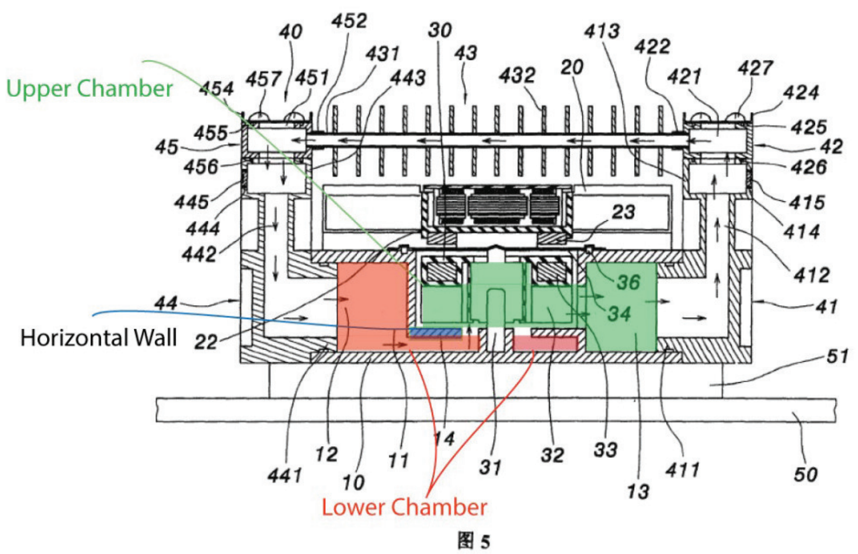
579. To the extent this limitation was not disclosed or taught by Yu, it would have been obvious to a POSA, based on her experience, education, and training, as I have already discussed with respect to Ground 1. I adopt that prior analysis here. A POSA would have been motivated to circulate cooling liquid through the reservoir because such an arrangement is an efficient way to bring cooling liquid from the pump to the heated region and thereby transfer heat from the heat-generating component into the cooling fluid. In addition, using a reservoir to route fluid reduces the number of fluid couplings, the potential for leaks and improves the performance of the system.

580. Furthermore, this limitation is also disclosed by Batchelder, as I have already discussed in connection with Ground 1. I adopt that prior analysis here.

1(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls

581. Yu discloses or teaches this limitation, it possesses an upper chamber and a lower chamber wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are surrounded by boundary walls.

582. For example, Yu discloses a reservoir that includes upper and lower chambers that are vertically spaced apart.



Yu, Figure 5

583. To the extent this was not disclosed or taught from Yu, it would have been obvious based on Batchelder, as I have already discussed in connection with Ground 1. I adopt that

previous analysis here. A POSA would have been motivated to use an upper and a lower chamber of a reservoir that are vertically displaced and each surrounding by boundary walls. This arrangement is a simplified way to route fluid to the heated region. The vertical arrangement reduces the space occupied by the cooling system and simplifies assembly of the cooling system to the electronic system.

1(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber

584. Yu discloses a first passage that fluidly couples the lower chamber to the upper chamber wherein the first passage is substantially central to the lower chamber.

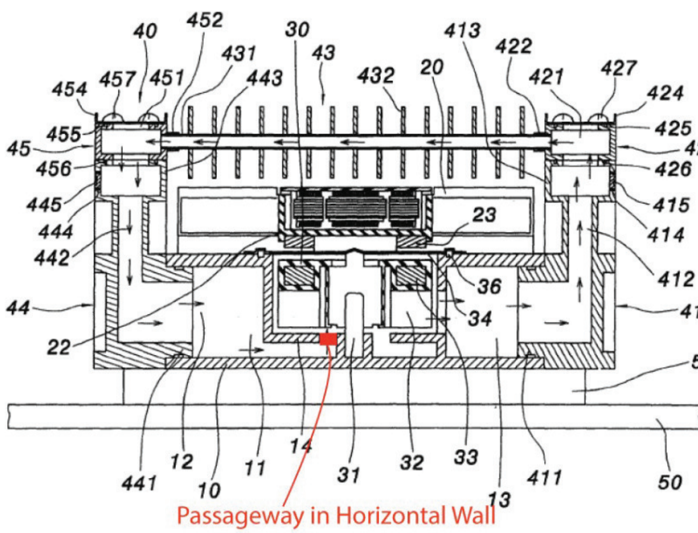


图 5

Yu, Figure 5

585. To the extent this was not disclosed or taught based on Yu alone, it would have been obvious based on the experience, education, and training of a POSA. A POSA would have known that the two chambers would be fluidly connected and that the fluid coupling would be accomplished with a passageway. The positioning of a fluid passageway near

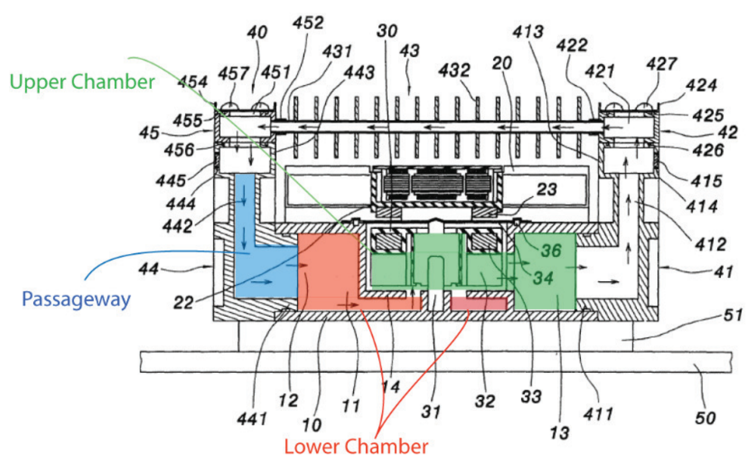
the center of the chambers is an obvious choice. A POSA would have been motivated to use a passage that couples the lower and upper chambers of a reservoir where the passage is substantially central to the lower chamber. Such an arrangement is a simple and hydraulically efficient way to route liquid to the heat generating region; it shortens the flow path and improves hydraulic performance.

586. To the extent this is not made obvious by Yu, it would have been obvious in view of Batchelder. Batchelder discloses a two-chamber reservoir that are fluidly connected by a passageway, as shown here, where one of the passageways is centrally located.

587. To the extent that this claim limitation was not disclosed or taught based on Yu in view of the knowledge of a POSA, it would have been obvious in further view of Batchelder as I have already discussed in regards to Ground 1. I adopt that prior analysis here.

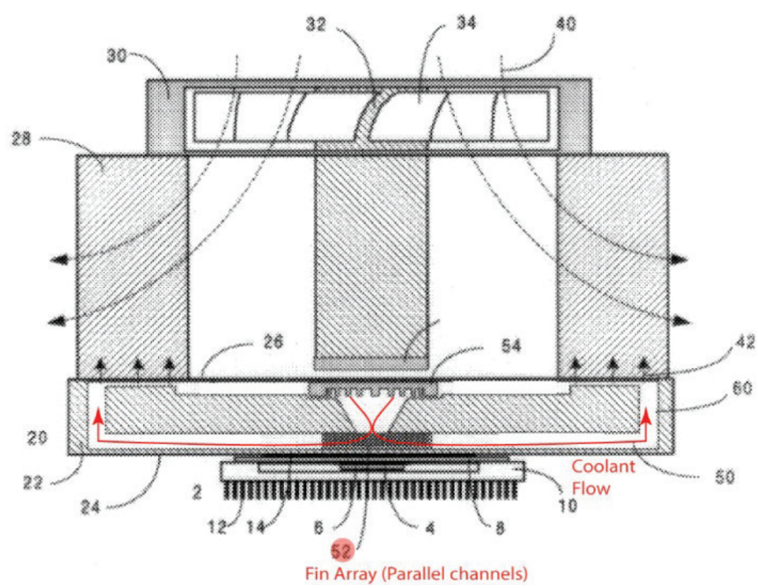
1(d) a second passage positioned at a perimeter of the lower chamber;

588. Yu discloses or teaches this limitation; Yu teaches a second passage positioned at a perimeter of a lower chamber.



Yu, Figure 5

589. To the extent that this limitation was not disclosed or taught by Yu, it was disclosed or taught by Batchelder, as discussed in Ground 1 and demonstrated in the following image. A POSA would have been motivated to include a second passage at the perimeter of the lower chamber because it would provide an unobtrusive way to remove the cooling fluid from the heated region so that the cooling fluid can be routed away and the heat contained within the cooling fluid can be transferred to the ambient environment.

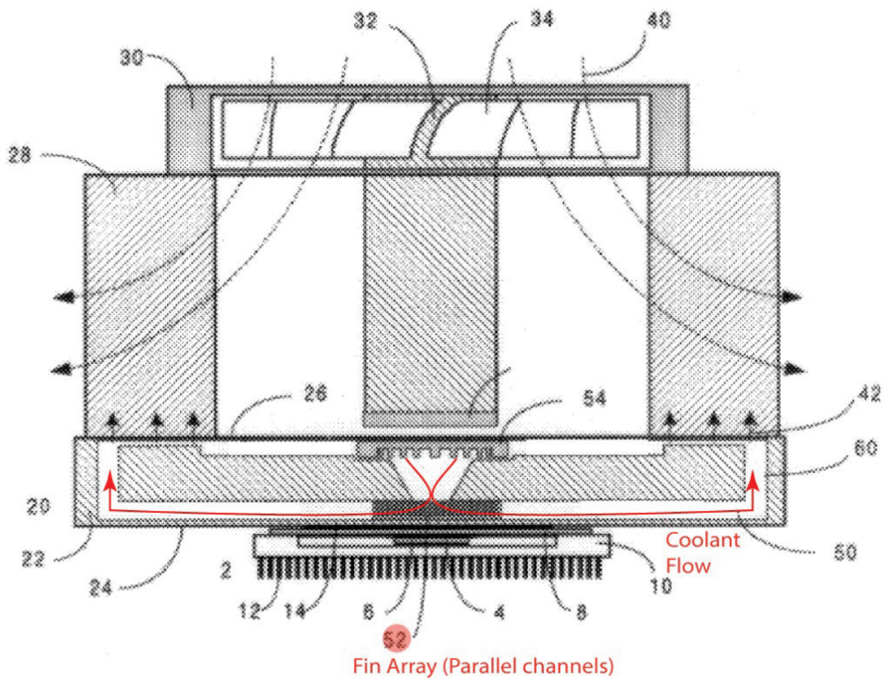


Batchelder, Figure 2

1(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage

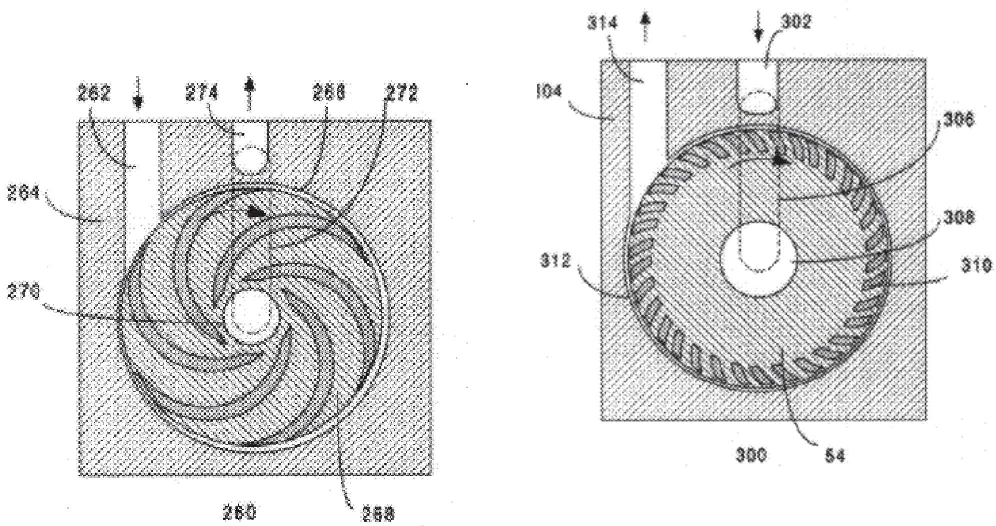
590. Yu, in view of Batchelder, discloses or teaches this limitation. Batchelder teaches a lower chamber with a plurality of parallel channels configured to split the flow of cooling liquid

and direct the cooling liquid from the central region toward the perimeter of the lower chamber, where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage; as discussed in Ground 1 and shown in the figure below.



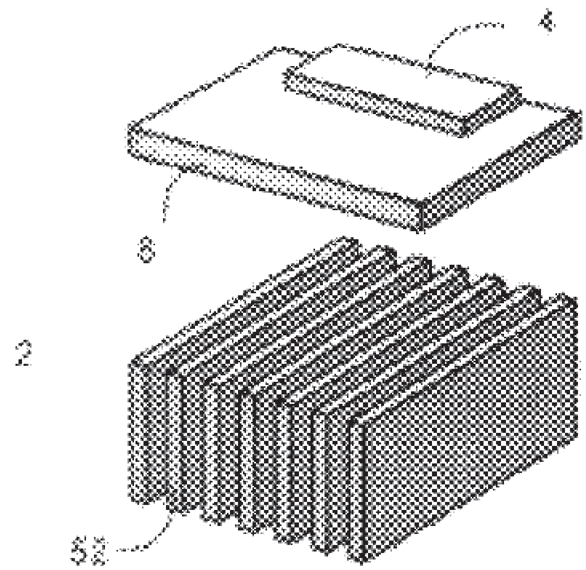
Batchelder, Figure 2

591. Batchelder teaches the use of pumps that provide flow in different directions, as shown by the following from Figure 9. With the pump on the left, the flow would be in the direction indicated by red arrows in the preceding paragraph.

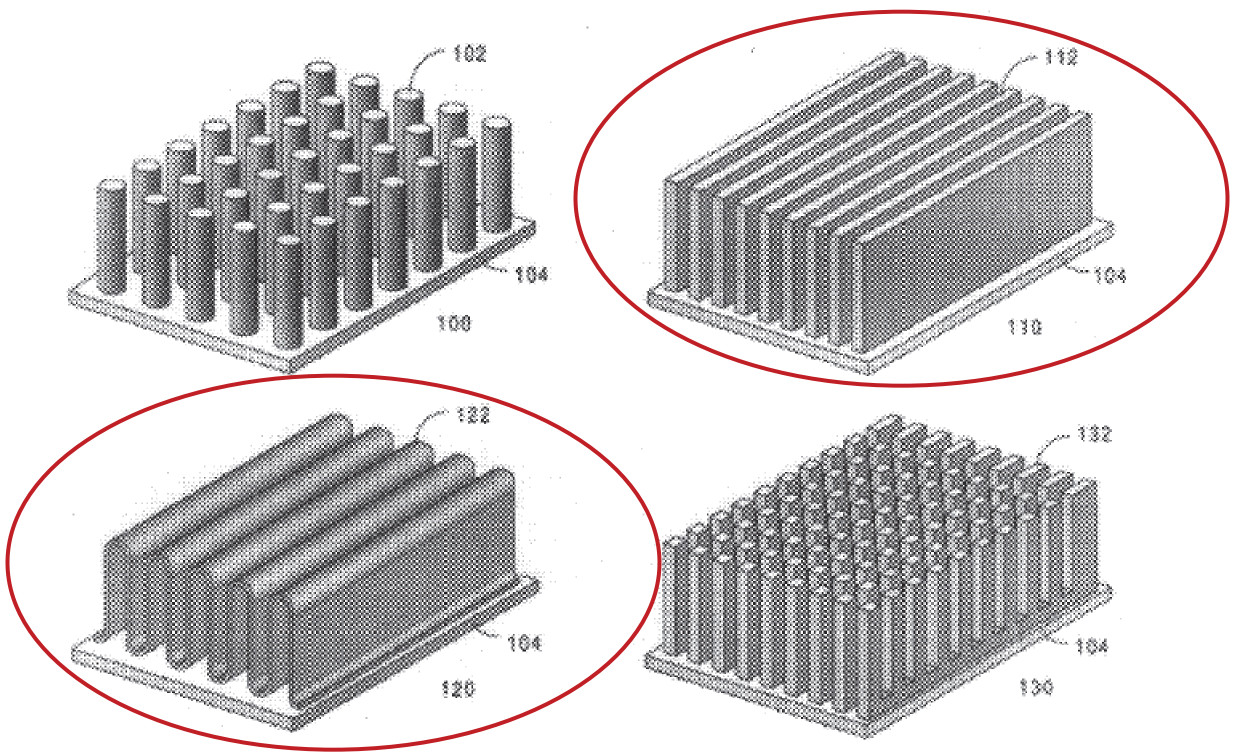


From Batchelder, Figure 9

592. Batchelder discloses parallel channels formed in the lower chamber that direct fluid. I adopt my discussion from Ground 1. The parallel channels are created by the fin array (52) that Batchelder discloses. A POSA would have been motivated to incorporate a lower chamber with a plurality of channels configured to split the flow of cooling liquid and direct the liquid from the central region toward the perimeter of the lower chamber where the fluid is collected. Such a flow design promotes effective cooling at the heated location and reduces pressure losses in the fluid. This improves the hydraulic performance of the pump and thus the efficiency of the cooling system. The use of channels increases the heat transfer surface area and thereby reduces the temperature of the heat-generating component.



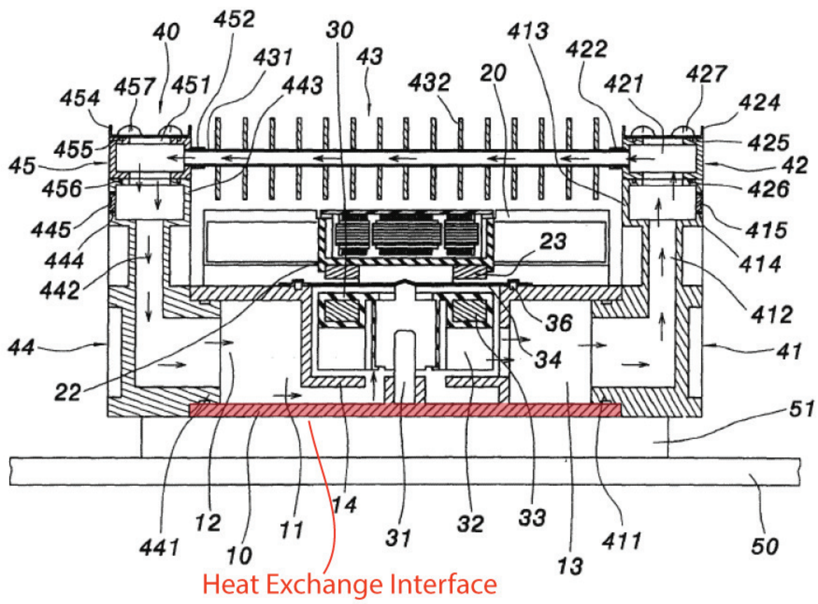
From Batchelder Figure 4



From Batchelder, Figure 6

1(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

593. Yu discloses or teaches this limitation. Yu teaches a heat exchanging interface that is attached to the reservoir to form a boundary wall of the lower chamber. The heat exchanging interface is configured to provide thermal contact between a processing unit and the cooling liquid.



Yu, Figure 5

594. To the extent this limitation was not disclosed or taught by Yu, it would have been obvious in view of the experience, education, and training of a POSA and/or further in view of Batchelder, as I have already discussed in Ground 1. I adopt that analysis here. A POSA would have been motivated to attach a heat exchanging interface to the reservoir to form a boundary wall of the lower chamber and to enable thermal contact between the

processing unit and the cooling liquid. Thermal contact reduces the thermal resistance and thereby lowers the temperature of the heat generating component.

1(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

595. This limitation is obvious in view of Yu. Yu discloses a pump having a motor and an impeller with the impeller positioned within the upper chamber of the reservoir.

Abstract

The invention discloses a liquid cooling radiator which comprises a base, a fan, a pump and a water circulation loop. The base has a reservoir inside. The reservoir has two ports and serves to store cooling water. The fan is arranged on the base and has a fan blade body driven by electricity to rotate. The pump is arranged oppositely to the fan blade body of the fan and is positioned inside the reservoir of the base. A magnetic connector unit is arranged between the fan blade body and the pump. The water circulation loop is connected with the two ports of the base. With the above arrangement, the invention has a water-cooling mechanism and forces the heat dissipation of heating electronic components such as CPU.

Yu, Abstract

The pump 30 is arranged below the fan 20, opposite to the fan blade body 22 of the fan 20 and inside the reservoir 11 of the base 10. The center of the pump 30 is fixed to the base 10 by the pivot 31, so that the pump 30 could is rotated. The pump 30 has an impeller 32, which could drive the cooling water to flow. The magnetic member (e.g. iron sheets) 33, which could be attracted to the magnet 23, is fixed on top of the pump 30.

Yu, Page 23

As shown in FIG. 5 and FIG. 6, the present invention could be attached to the CPU 51 on the motherboard 50 by its base 10, and could drive the pump 30 to rotate synchronously through the fan 20. The pump 30 could pump the cooling water which was inside the reservoir 11 through the base 10 out of the port 13. The water then passes through, sequentially, the first loop 41, the second loop 42, the third loop 43, the fourth loop 44 and the fifth loop 45 of the water circulation loop 40, and flows through the other port 12 of the base 10 into the reservoir 11, whereby the cooling water circulation can be established.

Therefore, the heat generated from the operation of the CPU 51 could be transferred to the base 10 and the water circulation loop 40. The material itself and the internal circulating water of the base 10 and the water circulation loop 40 could help with cooling. The circulating water could transfer the heat to the heat exchange cooling fin 432 to increase the cooling area, and can drive cold air with the fan 20 to flow through the base 10, water circulation 40 and out of heat exchange cooling fin 432 to achieve the cooling effect.

Yu, Page 25

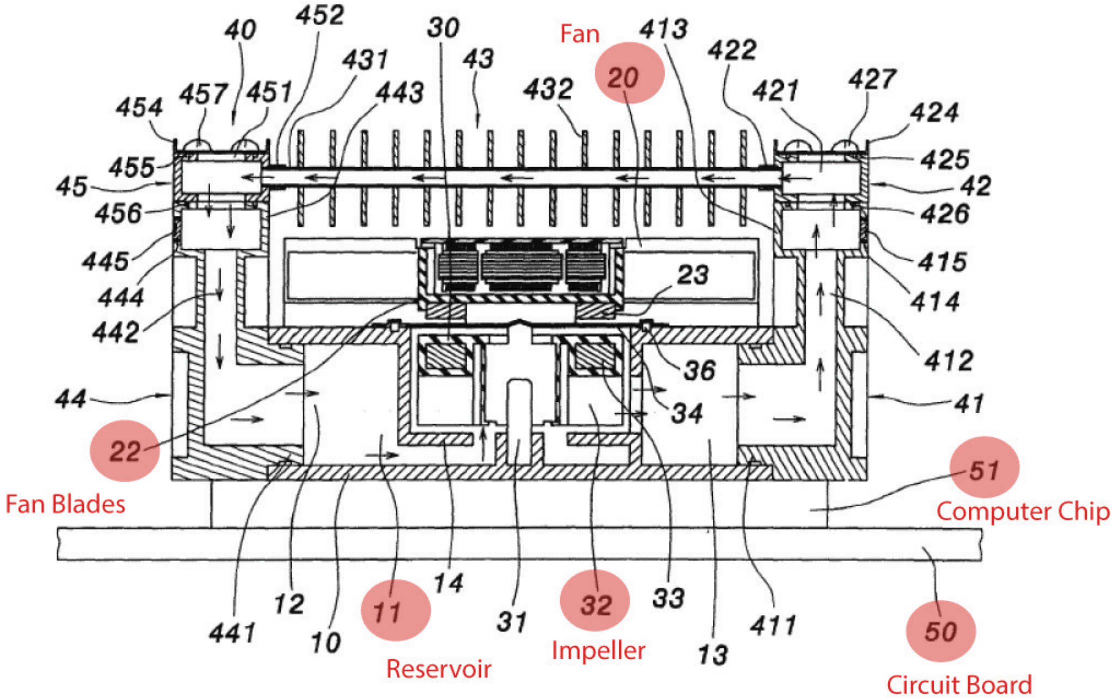
Claims

1. A liquid cooling radiator, characterized by, including:
   a base with a reservoir inside, and the reservoir has two ports and serves to store cooling water;
   a fan, which is arranged on the base and has a fan blade body driven to rotate;
   a pump, which is arranged oppositely to the fan blade body of the fan and is positioned inside the reservoir of the base;
   a magnetic connector unit, which is connected and positioned between the blade body and the pumping device;
   a water circulation loop, which is connected to the two ports of the base.

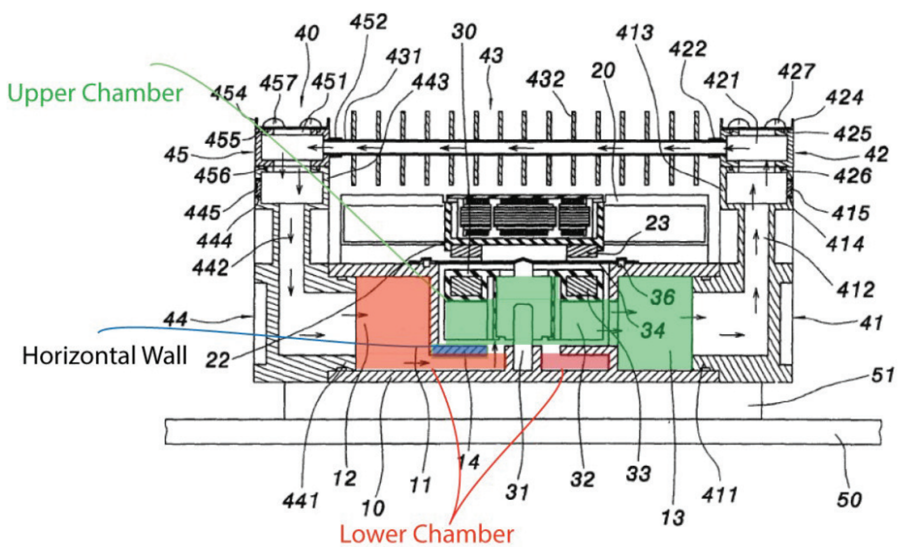
Yu, Claim 1

Please refer to FIG. 2, FIG.3 and FIG.4. This invention provides a liquid-cooling radiator apparatus, which includes a base 10, a fan 20, a pump 30, and a water circulation loop 40. The base 10 is made of metals of better heat dissipation rate, and has a reservoir 11. The reservoir 11 could store cooling water, and has a separator 14 inside, which could separate the interior of the reservoir 11 for suitable loops.

Yu, page 23



Yu, Figure 5



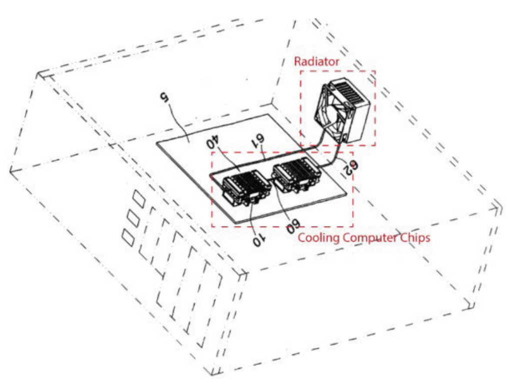
Yu, Figure 5

596. To the extent this limitation is not made obvious by Yu, it would have been obvious in light of the experience, education, and training of a POSA, or further in view of Batchelder, as I explained in Ground 1. I adopt that earlier discussion here. A POSA would have been motivated to use a pump with a motor and an impeller with the impeller positioned in the upper chamber of the reservoir. This design makes the flow hydraulically efficient and thus improves performances. In addition, this design reduces the size of the cooling system and also reduces the number of tubes and fluid connections, and thus lowers the risk of leaks.

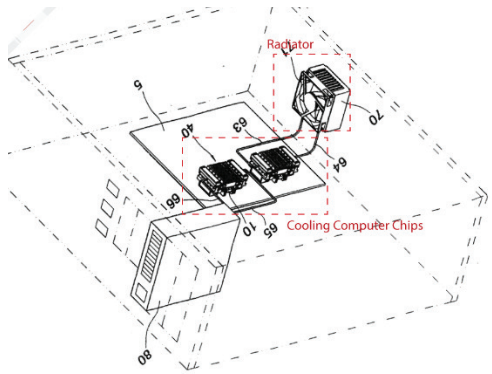
1(h) a radiator spaced apart from and fluidly coupled to the reservoir

597. Yu discloses the claimed radiator, spaced apart and fluidly coupled to the reservoir.

598. Yu teaches a separate cooling region (radiator) where heat is extracted from the coolant before the coolant is reintroduced to cool the electronic component(s). The following figures from Yu show a fan used to direct air across a radiator.



Yu, Figure 7



Yu, Figure 8

> The pump 30 is arranged below the fan 20, opposite to the fan blade body 22 of the fan 20 and inside the reservoir 11 of the base 10. The center of the pump 30 is fixed to the base 10 by the pivot 31, so that the pump 30 could is rotated. The pump 30 has an impeller 32, which could drive the cooling water to flow. The magnetic member (e.g. iron sheets) 33, which could be attracted to the magnet 23, is fixed on top of the pump 30.

Yu, Page 23

599. To the extent this limitation was not disclosed or taught by Yu, it would have been obvious based on the knowledge of a POSA or based on Batchelder, as I discussed in Ground 1. I adopt that analysis here. A POSA would have been motivated to implement a radiator that is spaced apart and fluidly coupled to the reservoir because this allows heat to be transferred from the vicinity of the heated region to the ambient environment, thus improving the performance of the system and lowering the temperature of the heat-generating component.

Claim 6 preamble: A cooling system for a computer system processing unit, comprising

600. To the extent this preamble is limiting, it was disclosed or taught by Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

601. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

602. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

603. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(d) a second passage positioned at a perimeter of the lower chamber;

604. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(e) wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber;

605. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

606. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

607. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(h) a radiator spaced apart from and fluidly coupled to the reservoir;

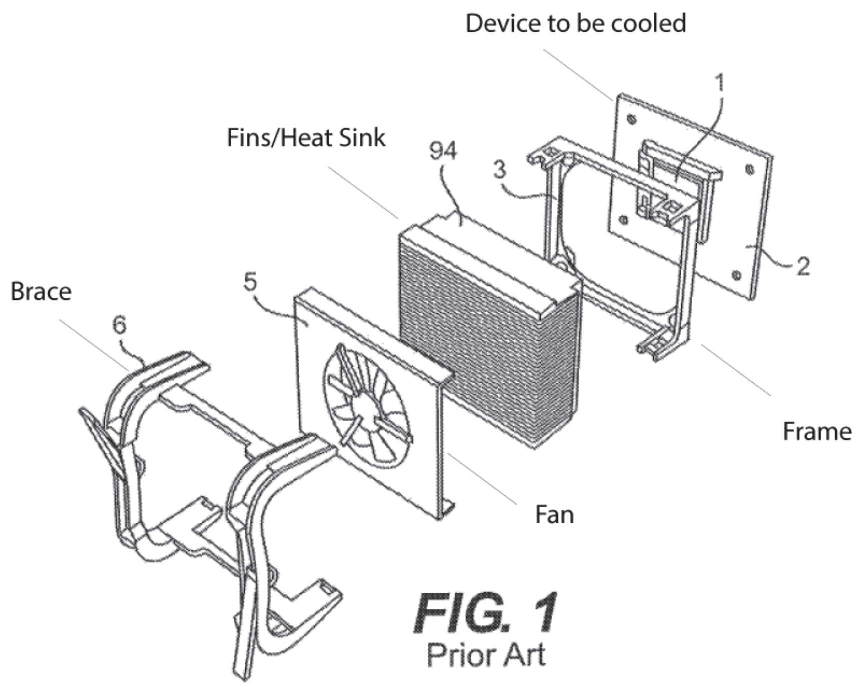
608. This claim limitation is disclosed in Yu either alone, or in view of the knowledge of a POSA or in view of Batchelder, for similar reasons as discussed in connection with Claim 1. I adopt that prior discussion here.

6(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

609. This claim limitation is obvious based on Yu, in view of the experience, education, and training of a POSA. Frames are commonly used to fasten a reservoir to a board on a computer system processing unit as I already discussed in Ground 1 and adopt here. As I have already discussed, Yu teaches the creation of thermal contact between the reservoir and the CPU. Thermal contact is important to ensure heat transfer from the CPU into the coolant. Reducing thermal resistance by use of a frame is commonly performed, I have on many occasions worked with, designed, or evaluated frames that are used in this way. Typically frames have holes that are used to facilitate a fastener (like a screw) that hold the cooling device in contact with the CPU.

610. In addition, this claim limitation is obvious based on the experience, education, and training of a POSA. In fact, the ’601 patent discloses prior art that contains such a frame,

as shown here. There, a frame (3) is identified which has four holes in its corners that correspond to the circuit board (2). A POSA would have been motivated to use a frame with four holes to fasten a reservoir to a board on which a CPU is configured. This promotes thermal contact and thus improved performance. It also reduces the likelihood that the cooling system will become dislodged from the heat-generating component.



’601 patent, Figure 1

6(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

611. For similar reasons to those I provided in Ground 1, this is obvious based on Yu, in light of the knowledge of a POSA and/or in light of Batchelder. I adopt that prior analysis here. A POSA would have been motivated to use a gasket to create a seal between the reservoir and the heat generating component to reduce the likelihood of leaks, result in vibration resistance, and to aid in assembly.

Claim 12 preamble: A cooling system for a computer system processing unit, comprising:

612. Yu, either alone, or in view of the knowledge of a POSA and/or Batchelder discloses this preamble, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

613. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

614. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

615. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(d) a second passage positioned at a perimeter of the lower chamber;

616. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

617. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

618. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

619. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(h) a radiator spaced apart from and fluidly coupled to the reservoir;

620. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

621. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

12(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

622. Yu, either alone, or in view of the knowledge of a POSA and/or in view of Batchelder discloses or teaches this limitation, for the same reasons as discussed in claim 1. I adopt that analysis here.

F. Ground 6 – Yu in View of Batchelder and Further in View of Nakano

623. It is my opinion that Yu, in view of Batchelder, further in view of Nakano, renders claim 11 of the ’601 patent obvious, for the reasons I will now discuss. Claim 11 depends from claim 7, which depends from claim 6, which is rendered obvious by Yu in view of Batchelder as discussed above, of which I adopt the prior analysis here.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

624. Yu, in view of the knowledge of a POSA, Batchelder, and Nakano discloses this claim, as I have already discussed regarding Grounds 1 and 2. I adopt that prior discussion here.

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

625. Yu, in view of the knowledge of a POSA, Batchelder, and Nakano discloses this claim, as I have already discussed regarding Grounds 1 and 2. I adopt that prior discussion here.

G. Ground 7 – Ryu in View of Batchelder

626. Ryu in combination with the experience, education, and training of a POSA and Batchelder, renders claims 1, 6, and 12 of the ’601 patent invalid, for the following reasons.

Claim 1 preamble: A cooling system for a computer system processing unit, comprising;

627. While I do not understand that the preamble to this claim is limiting, if it is limiting then Ryu discloses this preamble. First, Ryu is entitled "WATER COOLED COOLING DEVICE FOR THE CENTRAL PROCESSING UNIT OF A COMPUTER WITH AN IMPELLER"

628. Ryu further discloses the following:

Abstract

The present invention relates to a water-cooled cooling device for a computer's central processing unit having an impeller for circulating the water-cooled by a radiator inside a water jacket provided on the upper surface of the central processing unit of the computer to cool the heat generated from the central processing unit, and

Comprises a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit;

An impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and

A drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

Ryu, Abstract

Technical problems to be solved by the invention

The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for cooling the heat generated from the central processing unit using the circulating cooling water.

Ryu, Page 3

Comprises a pump driving unit having a first inlet, discharging unit, and a first outlet; and a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water, or

A pump driving unit having a first inlet, discharging unit, and a first outlet; a water jacket equipped and provided on the upper surface of the central processing unit from the lower portion of the pump driving unit and having a second inlet provided on an extension line of the first inlet to receive the cooled water, a water passage formed on the inside to circulate the cooled water received, and a second outlet formed to be open in the predetermined space formed at the lower portion of the discharging unit to discharge the circulated water; an inlet pipe exposed and formed between the water jacket and the pump driving unit to connect the first inlet and the second inlet; and a discharge pipe exposed and formed between the water jacket and the pump driving unit to connect the discharging unit and the second outlet, and in this case, it is preferable that the coupling clip mounts the water jacket to the central processing unit.

The water jacket is made of aluminum material, and specifically, a plurality of porous aluminum plates having a plurality of holes formed in a shape of a honeycomb is stacked and then joined by a brazing technique to form multiple water passages on the inside of the water jacket.

Ryu, Page 4

In order to achieve the said object, a water-cooled cooling device for computer central processing units having an impeller according to the present invention is a water-cooled cooling device for computer central processing units capable of cooling the central processing unit of a computer by receiving the cooled water and circulating therein, and is characterized by comprising a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit; an impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and a drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

In addition, it further comprises a coupling clip for mounting the combination of the circulation unit, impeller, and drive motor to the central processing unit,

Ryu, Page 4

In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit.

Ryu, Page 4

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, Page 5

As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

Ryu, Page 6

In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.[1]

Ryu, Page 7

629. To the extent this preamble was not disclosed or taught by Ryu, it would have been obvious in light of the knowledge of a POSA and/or in light of Batchelder, as I have discussed above. I adopt that analysis here. A POSA would have been motivated to use a cooling system for a computer system processing unit in order to remove heat and maintain safe CPU temperatures.

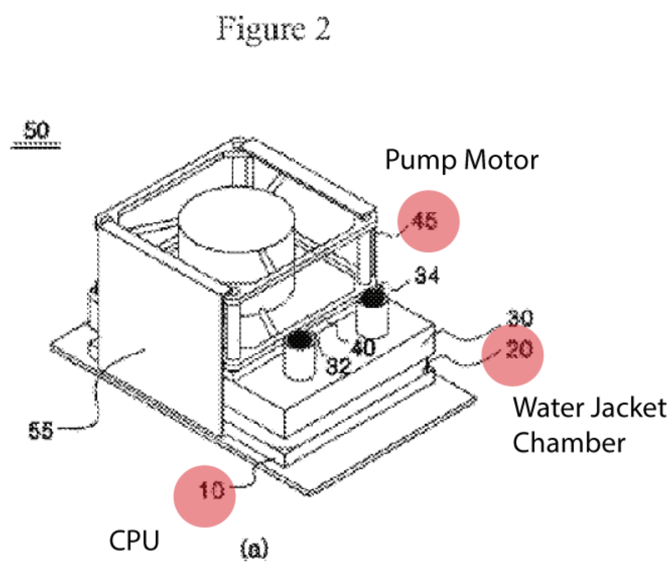
1(a) A reservoir configured to circulate a cooling liquid therethrough the reservoir including:

630. Ryu in view of Batchelder discloses or teaches this limitation. Ryu discloses or teaches the following:

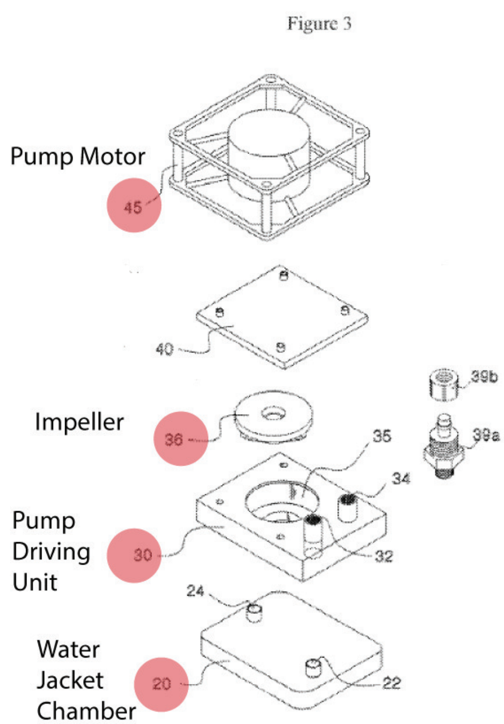
As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, page 5



Ryu, Figure 2



Ryu, Figure 3

631. Ryu does not disclose or teaches a "single receptacle," but it would have been obvious to modify Ryu based on the experience, education, and training of a POSA and Batchelder to render a "reservoir" obvious, as I have discussed above. I adopt that discussion here. A POSA would have been motivated to circulate cooling liquid through the reservoir because such an arrangement is an efficient way to bring cooling liquid from the pump to the heated region and thereby transfer heat from the heat-generating component into the cooling fluid. In addition, using a reservoir to route fluid reduces the number of fluid couplings, the potential for leaks and improves the performance of the system.

1(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls

632. As discussed above, Ryu discloses or teaches this limitation, of which I adopt that analysis. To the extent this claim limitation was not disclosed or taught by Ryu, it would have been obvious based on the knowledge of a POSA and/or in view of Batchelder, as I discussed above. I adopt that prior discussion here. A POSA would have been motivated to use an upper and a lower chamber of a reservoir that are vertically displaced and each surrounding by boundary walls. This arrangement is a simplified way to route fluid to the heated region. The vertical arrangement reduces the space occupied by the cooling system and simplifies assembly of the cooling system to the electronic system.

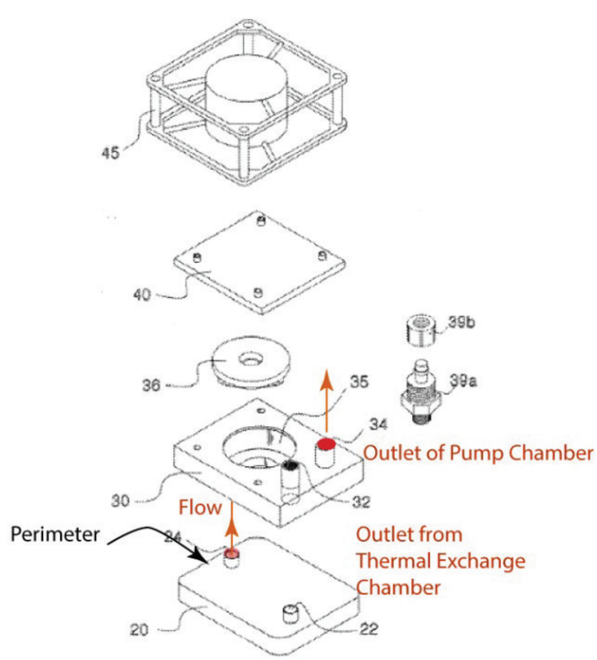
1(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber

633. This limitation was disclosed or taught by Ryu, in view of the knowledge of a POSA and/or in view of Batchelder, as I already discussed. I adopt that prior analysis here. A POSA would have been motivated to use a passage that couples the lower and upper chambers of a reservoir where the passage is substantially central to the lower chamber. Such an arrangement is a simple and hydraulically efficient way to route liquid to the heat generating region; it shortens the flow path and improves hydraulic performance.

1(d) a second passage positioned at a perimeter of the lower chamber;

634. Ryu discloses or teaches a fluid passage that couples the pump chamber with the thermal exchange chamber. The passage is configured to direct cooling liquid from the thermal exchange chamber to the pump chamber, the passage positioned at the perimeter of the thermal exchange chamber.

Figure 3



Ryu, Figure 3

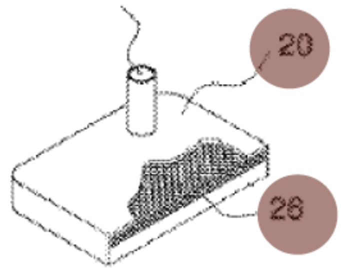
635. This limitation is further disclosed or taught by Ryu, in view of the knowledge of a POSA and/or in view of Batchelder, as I already discussed. I adopt that prior analysis here. A POSA would have been motivated to include a second passage at the perimeter of the lower chamber because it would provide an unobtrusive way to remove the cooling fluid from the heated region so that the cooling fluid can be routed away and the heat contained within the cooling fluid can be transferred to the ambient environment.

1(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage

636. Ryu discloses a lower chamber that includes a plurality of parallel channels configured to split the cooling flow and direct the cooling liquid from the central region toward the perimeter of the lower chamber, where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

> In addition, inside of the water jacket (20) is brazed after stacking a plurality of porous aluminum plates (26) to configure multiple water passages. More specifically, the honeycomb-shaped porous aluminum plate (26) is stacked and they are joined by spraying aluminum molecular power between the aluminum plates. Through this, the joined aluminum plates are recognized as mutually identical materials, and multiple water passages in the shape of a honeycomb is formed inside the water jacket (20). Therefore, the cooling water introduced into the water jacket is distributed and passes through multiple water passages formed inside the water jacket, thereby maximizing the heat exchange efficiency.

Ryu, page 7



Ryu, from Figure 4

637. To the extent this limitation was not disclosed or taught based on Ryu, it would have been obvious based on either the experience, education, and training of a POSA and/or in view of Batchelder, as I have already discussed. I adopt that prior discussion here. A POSA would have been motivated to incorporate a lower chamber with a plurality of channels configured to split the flow of cooling liquid and direct the liquid from the central region toward the perimeter of the lower chamber where the fluid is collected. Such a flow design promotes effective cooling at the heated location and reduces pressure losses in the fluid. This improves the hydraulic performance of the pump and thus the efficiency of the cooling system. The use of channels increases the heat transfer surface area and thereby reduces the temperature of the heat-generating component.

1(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

638. As seen above, Ryu includes a heat exchanging interface of a water jacket (lower surface of 20), that is coupled with the electronic component positioned on a motherboard.

639. Ryu discloses or teaches a heat-exchanging interface that forms a boundary wall of the lower chamber, the heat-exchanging interface is configured to be placed in thermal contact with a surface of the heat generating component and with an inner surface that defines a plurality of channels that direct the flow of cooling liquid within the thermal exchange chamber.

640. Ryu discusses the thermal contact between the heat-exchanging surface and the heat-generating component, for example:

As shown in FIG. 1, the water-cooled cooling device for a computer central processing unit having an impeller according to the present invention comprises a cooling unit mounted on the central processing unit to cool the heat generated from the central processing unit by passing the cooled water, and a radiator (60) for cooling the water heated by receiving the heat generated from the central processing unit while passing through the cooling unit. The cooling unit is mounted and provided on the upper surface of the central processing unit and the radiator (60) is mounted on the inside of the computer desktop (100) and preferably, mounted on the inside of the back surface of the desktop. In addition, a cooling fan (70) for cooling the water passing through the radiator is equipped on the front side or the rear side of the radiator (60).

The cooling unit comprises a water jacket (20) that is mounted on the upper surface of the central processing unit and where the cooled water passes through, a pump driving unit (30) for pumping the water, which has been heated by receiving the heat from the central processing unit while passing through the water jacket to the radiator (60) by discharging it through the rotational force of the impeller, and a drive motor (45) for driving the impeller. The water jacket, the pump driving unit, and the drive motor, which constitute the cooling unit, are mutually stacked, coupled, and arranged, and are mounted to the central processing unit by a coupling clip (55) while in the state of being coupled to each other. The coupling clip (55) is formed in a 'C' shape, and the lower portion is attached and fixed to the mainboard or the board at the lower portion of the central processing unit and the upper portion is coupled to the upper side of the drive motor to fix the cooling unit. In addition, since there is a possibility that water may leak from the connecting portion of the pump driving unit and the impeller, the upper portion of the pump driving unit and the impeller is sealed by covering it with a waterproof gasket (40). In this case, a silicon plate with the most excellent waterproofing property is used for the waterproof gasket.

Ryu, page 5

The water jacket (20) according to the present invention is mounted to the upper surface of the central processing unit (10) to cool the central processing unit (10) by receiving the cooling water discharged after being cooled in the radiator (60) through the pump driving unit (30) and having it pass through on the inside, and discharge the water, which has been heated by the heat transmitted from the central processing unit while passing through the inside, again to the radiator (60) through the pump driving unit (30). The water jacket (20) is

Ryu, Page 7

641. To the extent this limitation was not disclosed or taught based on Ryu, it would have been obvious based on either the experience, education, and training of a POSA and Batchelder to render the "reservoir" limitation obvious, as I have already discussed above. I adopt that prior discussion here. A POSA would have been motivated to attach a heat exchanging interface to the reservoir to form a boundary wall of the lower chamber and to enable thermal contact between the processing unit and the cooling liquid. Thermal contact reduces the thermal resistance and thereby lowers the temperature of the heat generating component.

1(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

642. Ryu discloses or teaches a motor and an impeller with the impeller positioned within the upper chamber.

Abstract

The present invention relates to a water-cooled cooling device for a computer's central processing unit having an impeller for circulating the water-cooled by a radiator inside a water jacket provided on the upper surface of the central processing unit of the computer to cool the heat generated from the central processing unit, and

Comprises a circulation unit equipped and provided on the upper surface of the central processing unit to receive cooled water, circulate it inside, and discharge it, and having a first inlet for receiving cooled water, a discharging unit formed in a groove shape to be caved in so that the water circulated inside can be discharged and gathered, and a first outlet provided at one side of the discharging unit to discharge the water gathered in the discharging unit;

An impeller equipped and provided on the discharging unit of the circulation unit and having a plurality of rotor blades on the bottom surface to discharge the water from the discharging unit to the first outlet by the rotating force; and

A drive motor equipped and provided on the upper portion of the impeller to drive the impeller by receiving power from the outside and transmitting the driving force to the impeller.

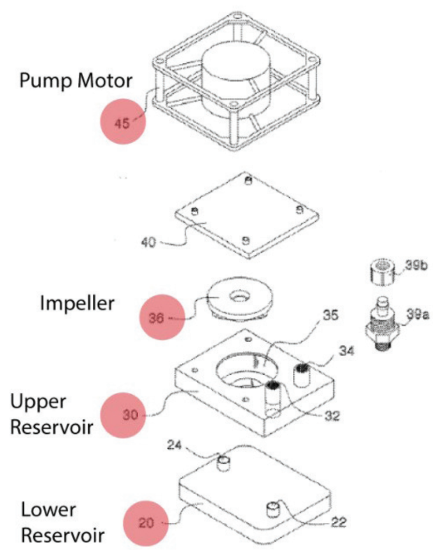
Ryu, Abstract

Technical problems to be solved by the invention

The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for cooling the heat generated from the central processing unit using the circulating cooling water.

Ryu, Page 3

Figure 3



Ryu, Figure 3

643. To the extent this was not disclosed or taught based on Ryu alone, it would have been obvious based on the experience, education, and training of a POSA and Batchelder to render the "reservoir" limitation obvious, for the reasons I have discussed above. I adopt that discussion here. A POSA would have been motivated to use a pump with a motor

and an impeller with the impeller positioned in the upper chamber of the reservoir. This design makes the flow hydraulically efficient and thus improves performances. In addition, this design reduces the size of the cooling system and also reduces the number of tubes and fluid connections, and thus lowers the risk of leaks.

1(h) a radiator spaced apart from and fluidly coupled to the reservoir

644. Ryu discloses or teaches a radiator spaced apart from and fluidly connected to the reservoir, as shown here:

Two tubes (66, 68) connecting the pump driving unit (30) and the radiator (60) are provided between the cooling unit and the radiator to circulate the water that has passed through the water jacket (20) and the cooling water. Therefore, the water that has been cooled while going through the radiator (60) is discharged through the outlet tube (66), goes through the pump driving unit (30), and is introduced to the water jacket (20), and the water that has passed through the water jacket goes through the pump driving unit to be introduced to the radiator through the inlet tube (68). When connecting the inlet tube and the outlet tube to the inlets (32, 62) and outlets (34, 64) of the pump driving unit and the radiator, they should be firmly tightened using connecting bolts and nuts to prevent water leakage from the connecting portion. In addition, the outlet tube (66) can also be connected directly to the water jacket (20) without connecting to the pump driving unit (30) to allow the cooling water discharged from the radiator (60) to be introduced directly to the water jacket without going through the pump driving unit.

Ryu, page 5

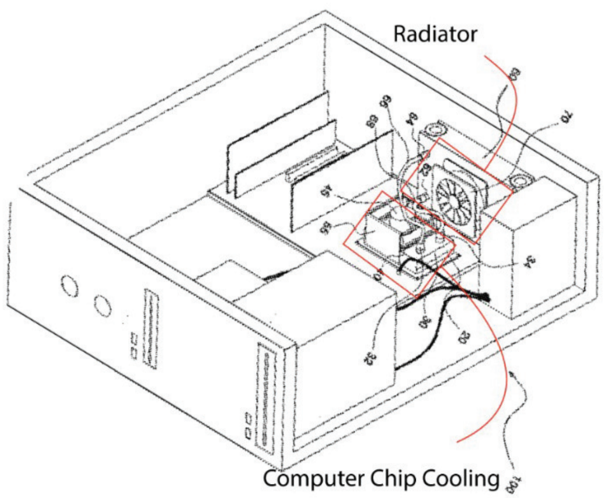
The radiator (60) performs cooling by the operation of the cooling fan (70) while circulating the water for which the temperature has risen while passing through the water jacket (20). In this case, the cooling fan (70) may be provided at the front side of the radiator to circulate the internal air of the computer desktop (100), or it may be provided at the rear side of the radiator and a plurality of holes may be formed on the back surface of the computer desktop to have the cooling fan circulate the air from the outside, thereby enhancing the cooling efficiency of the radiator. The location of the cooling fan (70) may be freely changed according to the situation of the system.

Ryu, Page 6

As described above, the cooling water that has been cooled in the radiator (60) flows through the pump driving unit (30) and into the water jacket (20) to cool the central processing unit (10) arranged at the lower portion of the water jacket, and the water that has passed through the water jacket (20) is discharged through the radiator (60) again through the pump driving unit (30). More specifically, the cooling water discharged from the radiator (60) and through the outlet tube (66) flows into the inlet (32) of the pump driving unit (30) and then into the inlet (22) of the water jacket (20) interconnected with the inlet of the pump driving unit. In addition, the water that has passed through the water jacket (20) is discharged to the pump driving unit (30) through the outlet (24) of the water jacket and then discharged to the outlet (34) of the pump driving unit by the operation of the impeller to flow through the inlet tube (68) and into the radiator (60).

A first water passage for introducing the cooling water, which has been introduced from the radiator to the inlet, to the water jacket (20) and a second water passage for connecting the water, which has been discharged from the water jacket, to the outlet are penetrated and formed on the inside of the pump driving unit (30), and each water passage is interconnected with the inlet (22) and the outlet (24) of the water jacket (20).

Ryu, page 6



Ryu, Figure 1

645. To the extent this was not disclosed or taught considering Ryu alone, it would have been obvious based on the knowledge of a POSA and/or based on Batchelder, as explained above. I adopt that prior analysis here. A POSA would have been motivated to implement a radiator that is spaced apart and fluidly coupled to the reservoir because this allows heat

to be transferred from the vicinity of the heated region to the ambient environment, thus improving the performance of the system and lowering the temperature of the heat-generating component.

Claim 6 preamble: A cooling system for a computer system processing unit, comprising

646. To the extent this preamble is limiting, it was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

647. This limitation was disclosed or taught by Ryu in view of the knowledge of a POSA and Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

648. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

649. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(d) a second passage positioned at a perimeter of the lower chamber;

650. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(e) wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber;

651. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

652. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

653. This limitation was disclosed or taught by Ryu in view of the knowledge of a POSA and Batchelder to render the "reservoir" limitation obvious, for similar reasons as discussed above. I adopt that prior discussion here.

6(h) a radiator spaced apart from and fluidly coupled to the reservoir;

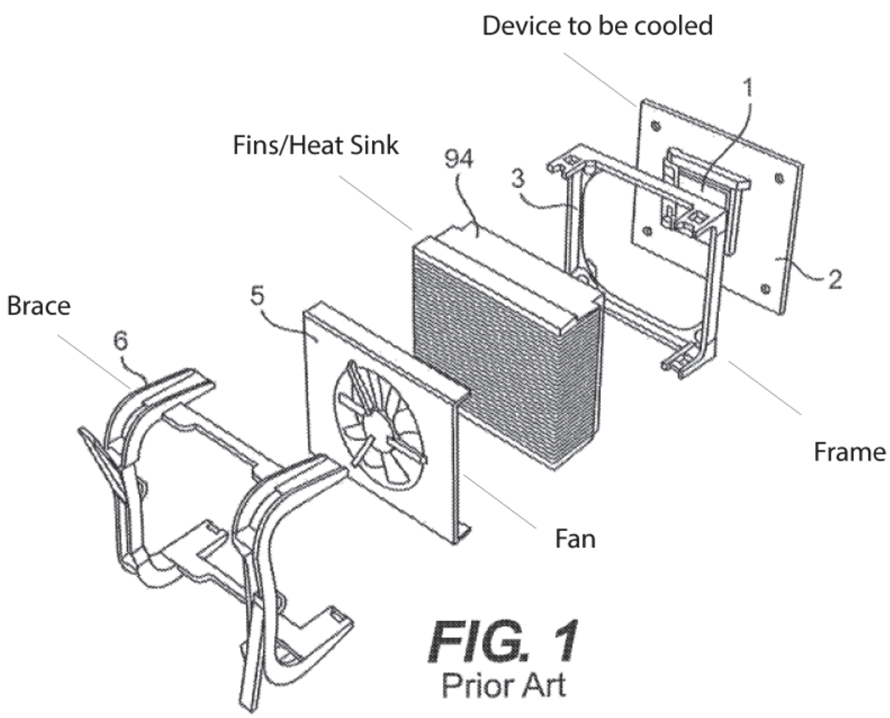
654. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

6(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

655. This claim is obvious based on Ryu in view of the experience, education, and training of a POSA. Frames are commonly used to fasten a reservoir to a board on a computer system processing unit. As I have already discussed, Ryu teaches the creation of thermal contact between the reservoir and the CPU. Thermal contact is important to ensure heat transfer from the CPU into the coolant. Reducing thermal resistance by use of a frame is commonly performed, I have on many occasions worked with, designed, or evaluated frames that are used in this way. Typically frames have holes that are used to facilitate a fastener (like a screw) that hold the cooling device in contact with the CPU. A POSA would have been motivated to use a frame with four holes to fasten a reservoir to a board on which a CPU is configured. This promotes thermal contact and thus improved

performance. It also reduces the likelihood that the cooling system will become dislodged from the heat-generating component.

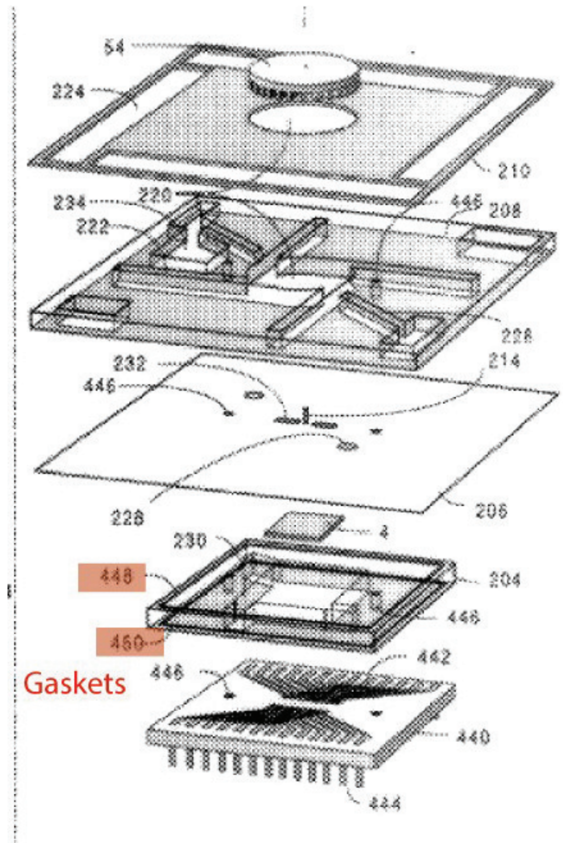
656. As evidence by the ubiquitous nature of such frames, I have included prior art figure 1, from the ’601 patent (as with my discussion in Ground 1, which I adopt here). There, a frame (3) is identified which has four holes in its corners that correspond to the circuit board (2).



’601 patent, Figure 1

6(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

657. Ryu does not expressly disclose or teach a gasket, but gaskets are ubiquitous in liquid pumps and in thermal management of electronic systems. For instance, gaskets are expressly called out in Batchelder, as shown here.



Batchelder, Figure 13

658. To the extent this was not disclosed or taught in view of Batchelder, it would have been obvious to use a gasket, based on the experience, education, and training of a POSA. A POSA would have known that gaskets are used at interfaces between fluid-conveying structures to reduce or eliminate leaks at those interfaces. Gaskets, such as O-rings, are commonly used in even the most rudimentary engineering systems. A POSA would have been motivated to use a gasket to create a seal between the reservoir and the heat generating component to reduce the likelihood of leaks, result in vibration resistance, and to aid in assembly.

Claim 12 preamble: A cooling system for a computer system processing unit, comprising:

659. To the extent this preamble is limiting, it was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(a) a reservoir configured to circulate a cooling liquid therethrough, the reservoir including:

660. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(b) an upper chamber and a lower chamber, wherein the upper chamber and the lower chamber are vertically displaced fluid-containing chambers that are each surrounded by boundary walls.

661. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(c) a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber;

662. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(d) a second passage positioned at a perimeter of the lower chamber;

663. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(e) wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage.

664. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(f) a heat exchanging interface attached to the reservoir to form a boundary wall of the lower chamber, the heat exchanging interface configured to provide thermal contact between a processing unit and the cooling liquid;

665. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(g) a pump having a motor and an impeller, the impeller being positioned within the upper chamber of the reservoir; and

666. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(h) a radiator spaced apart from and fluidly coupled to the reservoir;

667. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(i) a frame configured to fasten the reservoir to a board on which a computer system processing unit is configured to be mounted, wherein the frame has four holes, one provided in each corner of the frame configured to correspond to holes in the board;

668. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

12(j) a gasket configured to seal between the reservoir and the heat exchanging interface.

669. This limitation was disclosed or taught by Ryu either alone, or in view of the knowledge of a POSA and/or in view of Batchelder, for similar reasons as discussed above. I adopt that prior discussion here.

H. Ground 8 – Ryu in View of Batchelder and Further in View of Nakano

670. Ryu, in view of the experience, education, and training of a POSA, and in view of Batchelder and Nakano render claim 11 of the '601 patent invalid, for the following reasons. Claim 11 depends from claim 7, which depends from claim 6, which is rendered obvious by Yu in view of Batchelder as discussed above, of which I adopt the prior analysis here.

Claim 7: The cooling system of claim 6, wherein the cooling system is further configured to function with a control system, wherein the control system is configured to adjust to a speed of the pump.

671. Ryu in view of the experience, education, and training of a POSA, and in view of Batchelder and Nakano practice this limitation, for the reasons already discussed above; I adopt that earlier discussion here.

Claim 11: The cooling system of claim 7, wherein the cooling system is further configured to function with a control system that can adjust a rotational speed of a fan and a rotational speed of the pump to reduce noise and provide a required cooling capacity of the cooling system.

672. Ryu in view of the experience, education, and training of a POSA, and in view of Batchelder and Nakano practice this limitation, for the reasons already discussed above; I adopt that earlier discussion here.

X. ANALYSIS OF VALIDITY OF THE ’355 PATENT PURSUANT TO 35 U.S.C. §§ 102 AND 103

673. It is my understanding that all of the asserted claims of the ’355 patent have been determined by the Patent Trial and Appeal Board (“PTAB”) to be unpatentable as set forth in a Final Written Decision dated August 19, 2021.

674. It is also my understanding that the allegations of invalidity raised by CoolIT in the IPR – as well as any allegations that reasonably could have been raised – will not be alleged in this case for legal reasons about which I am not offering an opinion.

675. It is also my understanding that Asetek may appeal the findings of the PTAB and that CoolIT has requested that the court stay this case until the Federal Circuit has heard and decided the appeal.

676. It is also my understanding that, if the court does not grant the stay and that if Asetek continues to assert the ’355 patent claims that have been found unpatentable by the PTAB then CoolIT may seek to allege invalidity of the asserted claims of the ’355 patent based on the findings of the PTAB as well as with respect to additional prior art.

677. In the event the court allows CoolIT to assert the invalidity of the ’355 patent, I am prepared to offer additional opinions on the invalidity of the ’355 patent and reserve the right to supplement this report accordingly.

678. For example, I have studied the Final Written Decision, and it is my opinion that the challenged claims of the ’355 patent are invalid for at least the reasons set forth by the PTAB in the Final Written Decision.

679. Further, it is my opinion that asserted claim 1 of the ’355 patent is nearly identical to asserted claim 1 of the ’196 patent. Claim 1 of the ’196 patent requires an additional limitation that claim 1 of the ’355 patent does not require and thus claim 1 of the ’355

patent is broader than claim 1 of the ’196 patent. Accordingly, it is my opinion that claim 1 of the ’355 patent is invalid for at least the same reasons that claim 1 of the ’196 patent is invalid as set forth above.

680. Further, it is my opinion that asserted dependent claim 2 of the ’355 patent adds the same limitation to claim 1 of the ’355 patent as asserted dependent claim 2 of the ‘196 patent adds to claim 1 of the ’196 patent. Accordingly, it is my opinion that claim 2 of the ’355 patent is invalid for at least the same reasons that claim 2 of the ’196 patent is invalid as set forth above.

681. Further, it is my opinion that asserted dependent claim 6 of the ’355 patent adds the same limitation to claim 1 of the ’355 patent as: (a) asserted dependent claim 13 of the ’196 patent adds to claim 10 of the ’196 patent; (b) dependent claim 6 adds to asserted claim 1 of the ’196 patent. Accordingly, it is my opinion that claim 6 of the ’355 patent is invalid for at least the same reasons that claims 1 and 13 of the ’196 patent are invalid as set forth above.

682. Given the similarities of the claims between those in the ’355 patent and the ’196 patent, the PTAB’s Final Written Decision is consistent with and tends to support my invalidity analyses on the claims of the ’196 patent claims.

XI. ANALYSIS OF VALIDITY OF THE ’354 PATENT PURSUANT TO 35 U.S.C. § 103

683. It is my understanding that all of the asserted claims of the ’354 patent have been determined by the PTAB to be unpatentable as set forth in a Final Written Decision dated August 19, 2021.

684. It is also my understanding that the allegations of invalidity raised by CoolIT in the IPR – as well as any allegations that reasonably could have been raised – will not be alleged in this case for legal reasons about which I am not offering an opinion.

685. It is also my understanding that Asetek may appeal the findings of the PTAB and that CoolIT has requested that the court stay this case until the Federal Circuit has heard and decided the appeal.

686. It is also my understanding that, if the court does not grant the stay and that if Asetek continues to assert the '354 patent claims that have been found unpatentable by the PTAB then CoolIT may seek to allege invalidity of the asserted claims of the '354 patent based on the findings of the PTAB as well as with respect to additional prior art.

687. In the event the court allows CoolIT to assert the invalidity of the '354 patent I am prepared to offer additional opinions on the invalidity of the '354 patent and reserve the right to supplement this report accordingly.

688. For example, I have studied the Final Written Decision and it is my opinion that the challenged claims of the '354 patent are invalid for at least the reasons set forth by the PTAB in the Final Written Decision.

689. Further, it is my opinion that asserted claim 1 of the '354 patent is nearly identical to asserted claim 1 of the '601 patent. Claim 1 of the '601 patent requires an additional limitation that claim 1 of the '354 patent does not require and thus claim 1 of the '354 patent is broader than claim 1 of the '601 patent. Accordingly, it is my opinion that claim 1 of the '354 patent is invalid for at least the same reasons that claim 1 of the '601 patent is invalid as set forth above.

690. Further, it is my opinion that asserted claim 8 of the ’354 patent is nearly identical to asserted claim 6 of the ’601 patent. Claim 6 of the ’601 patent requires additional limitations that claim 8 of the ’354 patent does not require and thus claim 8 of the ’354 patent is broader than claim 6 of the ’601 patent. Accordingly, it is my opinion that claim 8 of the ’354 patent is invalid for at least the same reasons that claim 6 of the ’601 patent is invalid as set forth above.

691. Further, it is my opinion that asserted claim 15 of the ’354 patent is nearly identical to asserted claim 12 of the ’601 patent. Claim 12 of the ’601 patent requires additional limitations that claim 15 of the ’354 patent does not require and thus claim 15 of the ’354 patent is broader than claim 12 of the ’601 patent. Accordingly, it is my opinion that claim 15 of the ’354 patent is invalid for at least the same reasons that claim 12 of the ’601 patent is invalid as set forth above.

692. Given the similarities of the claims between those in the ’354 patent and the ’601 patent, the PTAB’s Final Written Decision is consistent with and tends to support my invalidity analyses on the claims of the ’601 patent claims.

XII. MOTIVATION TO COMBINE CITED PRIOR ART

693. In this report, I have analyzed multiple prior-art publications or references that discuss or address the same or substantially similar underlying systems, projects, or other subject matters, such as patents, patent applications, and successive versions thereof, or multiple publications discussing the same or similar subject matters. Where multiple references discuss or relate to the same or related underlying projects, systems, or other subject matters, it was obvious to combine the discussions and disclosures of the references as

they would have been understood by a POSA to create systems with the combined features or potential features of the underlying projects, systems, techniques, or other subject matters. A POSA would have been motivated to combine the discussions and disclosures of one or more prior-art references with those of the others to improve the overall performance of the combine systems, as the combination of these features from two or more prior-art references would have produced predictable results and successes. Further, where one reference cites or discusses other references or their teachings, or references have one or more authors in common and a related area of subject matters, it was obvious to consider the teachings of the references in combination with each other due to the express relationships and commonalities between the references.

694. The cited references in my report are all directed at liquid cooling technologies that involve similar and/or related structures. For example, Duan discloses: "The computers are developed with more powerful function and computation speed. Beside performance issue, the product appearance, the construction and motherboard connection ways are also under extensive exploited. As downsize of form factor and increasing of processing speed, the heat dissipation for central processing unit (CPU) is also an important issue to Solve." Duan at [0004]. "However, above-described prior art liquid-cooling heat dissipation system 100a is composed of separate heat dissipation stage 10a, water pump 20a, cooling stage 30a and water tank 4.0a and ducts 103a, 104a, 304a and 402a interconnecting between above devices. The liquid-cooling heat dissipation system 100a thus formed is bulky and hard to assemble. This is adverse to the compact trend of computer. The present invention provides a cooling plate module wherein the cooling plate is integrally formed with the liquid driving module Such that the layout of the

cooling plate module can be minimized to reduce space. The present invention further provides a cooling plate module, wherein there is no duct connecting between the cooling plate and the liquid driving module, the stagnant problem caused by pressure difference can be prevented and the cool liquid can directly flush the heat-dissipating plates for enhancing heat dissipation efficiency." Duan at [0006] – [0008] (internal paragraph numbers omitted).

695. Shin similarly discloses: "The present invention pertains to a cooling structure for liquid cooling of heat generating electronic circuit components such as LSI chips installed on a wiring board, relating in particular to a cooling structure for compactly mounting a liquid cooled heat sink and pump. … In recent years, the amount of heat generated by electronic equipment, as represented by computers, communication equipment, multimedia equipment, etc., has tended to increase markedly. In particular, the cooling of CPUs, which perform centralized computation processing, image processing LSI chips, power amplifiers and the like, has become a very important problem. Furthermore, as the cooling scheme, conventionally, an air cooling scheme combining air cooling fins with a fan has been frequently used. However, air cooling schemes have a low cooling limit compared to liquid cooling schemes, so recently, schemes have been considered for liquid cooling of high heat output LSI chips such as CPUs alone using a liquid coolant such as water. For example, Japanese Unexamined Patent Application Publication H8–32262 discloses a liquid cooling scheme as illustrated in FIG. 4. LSI chips 51, which do not have a high heat output and can be air-cooled, and LSI chips which are cooled by a water cooled heat sink 40 due to their high heat output, are installed on the same wiring board 50. The air-coolable LSI chips 51 are air-cooled by means of two fans 47. Cooling

air is supplied from outside, as shown by 48, and is exhausted as shown by 49. The water cooled heat sink 40 installed on LSI chips of high heat output is connected via a hose 41 to an outlet pipe 42, and the cooling water warmed at 40 is cooled in heat exchanger 43 by the air of the fans 47. The cooled cooling water flows through coolant pipe 44 to pump 45 and is pressurized and then passes through inlet pipe 46 and is supplied again to the water cooled heat sink 40. … In the cooling structure disclosed in Japanese Unexamined Patent Application Publication H8–32262, the pump 45 is installed away from the wiring board 50 and water cooled heat sink 40, so space for mounting the pump 45 is required inside the case separately from the space for the pipes which are connected to the pump 45, and so there is the problem that the electronic equipment case cannot be made compact. It is an object of the present invention to provide a cooling structure for electronic devices which is compact, has low noise, superior cooling performance and high reliability. … To achieve the aforesaid object, the present invention, assuming a cooling device for electronic equipment comprising a wiring board, a heat generating element including an electronic circuit component such as an LSI chip installed on the wiring board, a liquid cooled heat sink installed on the heat generating element in thermal contact therewith, and a pump which pressurizes and circulates a liquid coolant, adopts a structure wherein the pump is installed on the top part of the liquid cooled heat sink. Furthermore, the pump is secured to the top part of the liquid cooled heat sink, forming a structure that allows the pump and liquid cooled heat sink to be handled as an integral structure. Furthermore, a structure is formed wherein the liquid coolant discharge section of the pump is directly connected to the liquid cooled heat sink by means of a pipe, etc. Furthermore, an arrangement is adopted whereby the pump operates from a direct current

power supply. Moreover, a structure is formed whereby the pump is secured to the liquid cooled heat sink across a vibration absorption member or the like." Shin [0001] – [0011] (paragraph numbers omitted).

696. Because both Duan and Shin are attempting to solve similar issues and each disclose or teach known techniques that can be used for the other, a POSA, when reading Duan and Shin together, would have been motivated to combine them.

697. Similarly, Ryu, for example, discloses: "In recent years, due to the rapid development of technology, the data processing speed of the central processing unit (CPU) is also being improved at a rapid pace. On the other hand, since the heat generated by the operation of the central processing unit increases according to the processing speed of the central processing unit, the amount of heat generated from the central processing unit has also increased as the processing speed of the central processing unit has increased. In general, the central processing unit shows the optimum performance as its temperature is close to room temperature and if the temperature gets too high, the processing speed decreases and the possibility of error in the processing result also increases. Furthermore, if the heat generation amount of the central processing unit is too high, it may cause the computer to stop working, which may cause loss of data. If this phenomenon persists, expensive central processing units may fail or break. Therefore, in order to solve this problem, it is necessary to cool the heat generated from the central processing unit and an air-cooled cooler, which lowers the temperature of the central processing unit by the rotation of the cooling fan, was used in the past. The present invention has been presented to solve the problems described above, and the object of the present invention is to provide a water-cooled cooling device for the computer central processing unit having an impeller for

cooling the heat generated from the central processing unit using the circulating cooling water. In other words, the object is to provide a water-cooled cooling processing unit for computer central processing unit that is capable of lowering the temperature of the central processing unit by passing the water, which has been cooled while going through the radiator, through the water jacket equipped to the central processing unit and cooling and circulating the water, which has been warmed up by the heat generated from the central processing unit, by pumping it to the radiator through the pump driving unit." Ryu (pp. 2-4) (paragraph breaks omitted).

698. Because Duan, Shin, and Ryu are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reviewing these references together, would have been motivated to combine Duan and/or Shin with Ryu and vice versa.

699. Further, for example, Koga discloses: "A speed enhancement technology has been developed rapidly in the computer industry, so that a clock frequency of a CPU becomes substantially higher than a previous one. As a result, the CPU produces too much heat for a conventional heat sink to air-cool the CPU. Thus a cooling device of high power and high efficiency is vitally required. One of such cooling devices is disclosed in Japanese Patent Application Non-Examined Publication No. H07-142886. This cooling device circulates coolant through a substrate on which heat producing electronic components are mounted, thereby cooling the Substrate." Koga at 1:14-24. "The first conventional cooling device, however, needs cooler 103, radiator 104, pump 105 and a refilling tank (not shown) for refilling pump 105 with the coolant. Those elements are assembled into the cooling device, so that the device becomes bulky and complicated. As a result, it is

difficult to reduce the size of the device and the device becomes expensive. In other words, the first cooling device is basically fit for cooling a large size electronic apparatus, but is not suitable for a recent notebook-size computer which is compact, light-weight, slim, and carried in a variety of postures. The second cooling device can be used in a notebook-size computer; however, both of heat-receiving header 113 and heat-radiating header 114 are box-shaped and Substantially thick, which prevents the notebook-size computer from being slimmed. To be more specific, in the second cooling device, a reciprocating pump (not shown) is prepared in header 114. This pump has a rather narrower width than other pumps and works as the liquid driving mechanism; however, the thick ness of header 114 is specified by this pump, so that the overall thickness cannot be reduced. As a result, the notebook-size computer cannot be further slimmed." Koga at 2:14-35. "A cooling device of the present invention includes a radiator and a centrifugal pump of contact heat exchanger model, both disposed in a closed circulating channel in which coolant circulates. Heat-producing electronic components are brought into contact with the centrifugal pump, so that the coolant in the pump collects the heat off the electronic components due to its heat exchanger function, and the radiator of the cooling device dissipates the heat. The centrifugal pump includes a pump-casing made of highly heat conductive material and an impeller. The pump casing has a heat-receiving plane formed on a side face along an interior pump room, and a sucking channel prepared between the heat-receiving plane and an inner wall of the pump room. On the inner wall of the pump room, a recess is provided. In this recess, protrusions extending toward the impeller or dimples are provided. According to the present invention, the cooling device

of a simple structure, which allows downsizing and slimming down, is obtainable while its cooling efficiency is improved." Koga at 3:13-30.

700. Once again, because Duan, Shin, Ryu, and Koga are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reading them together, would have been motivated to combine Duan, Shin, and/or Ryu with Koga, and vice versa.

701. Wu in a similar manner, discloses: "During the past decades technologies in electronics have improved tremendously. Devices Such as microprocessors have been become one of the major electronic components in many products Such as TVs, radios, home appliances and computers and gradually become part of people's daily life. Transistors enabled people to make microprocessor more reliable, consume less power and have a higher working Speed. Further developments of the integrated circuits (ICs) allowed multiple electronic circuits to be combined on the Same chip. Since then, chip manufacturers tend to reduce the overall size of the microprocessors and concurrently increase the total number of transistors therein. Like many electronic devices, microprocessors have a range of operating temperature, below which the device would function well. Exceeding the operating temperature or an excessively high temperature would adversely affect the overall performance of the device. Exceeding continuously the operating temperature for a certain amount of time would result in device failure or damage. It is therefore understood that thermal management in present-day electronics plays a very important role, particularly when heat is generated during operation. The CPU produces heat during the operation of the computer. Heat must be quickly carried away from the CPU during the operation of the computer. Conventionally, thermal control is achieved by using a fan

to provide ambient air to the device. This type of cooling system generally requires a large Surface area So that more air can be directed to the device. However, manufacturers tend to develop chips in a compact size Such cooling system certainly does not meet the need. Other drawbacks of this type include slow heat transfer and energy-inefficient. Alternatively, a cooling system with water other than air can be used, and can be refrigerated rather than at the ambient temperature. Such cooling systems include those designed as Separate compartments, i.e., units for radiation and absorption. With Such Segregated components, leakage, Slow and unstable circulation resulted thereby leading to inefficient heat transfer. For example, U.S. Pat. No. 6,422,304 discloses an auxiliary cooling system for cooling a central processing unit (CPU) which includes an inner tube provided within an outer tube. A first end of the outer tube is attached to a fan and a Second end of the outer tube is attached to a housing of a computer adjacent the CPU. Inlet and outlet tubes are attached to a first end and Second end of the inner tube. A pump draws a cooling fluid from a cooling Source and passes the cooling fluid to the inner tube. As the cooling fluid passes through the inner tube, the temperature of the air within the outer tube is decreased. A fan is used to direct the cool air onto the CPU." Wu at 1:17-67. "Similarly, U.S. Pat. No. 6,166,907 discloses a CPU cooling system for use in a computer to dissipate heat from the CPU of the computer comprising a water tank holding a liquid coolant, radiators, a water circulation pipe assembly for circulation of the liquid coolant through the radiators, and a pump external to the water tank whereby the liquid coolant is pumped through the water circulation pipe assembly. However, as the above prior art system has separate compartments, more efficient radiation is desirable. Although use of water may remove the heat and reduce the temperature produced by

electronic components, there is still a need for the development of a Stable, rapid, high energy efficient, Small capacity, impact resistant and leakage-free cooling system." Wu at 2:11-24.

702. Once again, because Duan, Shin, Ryu, Koga and Wu are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reading them together, would have been motivated to combine Duan, Shin, Ryu, and/or Koga with Wu, and vice versa.

703. Likewise, Yu discloses: "The fast advances of the computer industry have enabled the progress in computing power. With the processing speed of the central processing unit (CPU) growing, the heat which it generates also increases accordingly. In order for the CPU to remain functional at its allowed temperature, the industry has designed a variety of radiators and radiating fans with greater radiating area to help the cooling of the CPU with higher temperature. Please refer to FIG. 1. A known radiator 10a of a CPU has multiple radiating fins 11a to increase the radiating area. The radiator 10a is affixed on the top of the CPU 30a. A fan 20a may also be attached on a top of the radiator 10a. Therefore, the radiator 10a and the fan 20a can help cooling and maintain the function of the CPU 30a at the allowed temperature. However, the known radiator is a solid material, transferring the heat through dissipation, the rate of which is much lower of that of the generation of heat during the operation of the CPU, hence the poor cooling efficiency. Furthermore, with the improvement of processing speed, it will be increasingly difficult for the conventional radiator and fans to realize its function. As inferred from the above statement, the above-mentioned known radiator device obviously contains its inconvenience and defects in terms of usage, and leaves something to be desired.

Therefore, as the applicator saw the room for improvement thereof, he has dedicated himself to research and applied scientific theory to the desired improvement, and finally put forward the present invention, which is a sensible design and significantly improves the above shortcomings." Yu at p. 22 (paragraph breaks omitted). "The primary objective of this invention is to provide a liquid-cooling radiator apparatus, which helps to force the cooling of the CPU through circulating cooling water and provides a more effective cooling method. Another objective of this invention is to provide a liquid-cooling radiator apparatus, wherein its fan is rotated synchronously with the pump and pumps the cooling water to circulate without additional power source needed. It is both space-saving and less costly. To achieve the above objective, this invention provides a liquid-cooling radiator apparatus comprising: a base with a reservoir inside; the reservoir with two ports which serves to store cooling water; a fan arranged on the base with a fan blade body driven to rotate; a pump arranged oppositely to the fan blade body of the fan and positioned inside the reservoir of the base; a magnetic connector unit arranged between the fan blade body and the pump; and a water circulation loop connected with the two ports of the base." Yu at pp. 22-23.

704. Once more, because Duan, Shin, Ryu, Koga, Wu, and Yu are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reading them together, would have been motivated to combine Duan, Shin, Ryu, Koga, and/or Wu, with Yu and vice versa.

705. In a similar manner, Batchelder discloses: "As the power to be dissipated by Semiconductor devices increases with time, a problem arises: within about ten years the thermal conductivity of the available materials becomes too low to conduct the heat from

the Semiconductor device to the fins with an acceptably low temperature drop. The thermal power density emerging from the chip will be So high in ten years than even copper or Silver spreader plates will not be adequate. A clear and desirable Solution to this problem is to develop inexpensive ways to manufacture more exotic materials like pyrolytic graphite or diamond that have even higher thermal conductivities. If the cost of these exotic materials does not fall quickly enough, an alternative solution is needed, such as will be discussed shortly." Batchelder at 1:30-43. "Many heat transfer Systems use an external Source of energy to pump a recirculating heat transfer fluid. Most of these do not incorporate the pumped heat transfer fluid in an active spreader plate geometry that can be implemented as a replacement for a passive spreader plate. Most of these incur the cost disadvantage of requiring Separate motors to impel the heat transfer fluid and to impel the atmosphere. Most of these incur the reliability disadvantage of using Sealed shaft feed-throughs to deliver mechanical power to the heat transfer liquid. Most incur the added assembly cost and reliability exposure associated with hoses and fittings. None of these existing heat transfer Systems simultaneously use a Single motor to drive an impeller for the heat transfer fluid and an impeller for the atmosphere, use moving external magnetic fields to eliminate a rotary seal, and use monolithic assembly without hoses or fittings." Batchelder at 1:62-2:10.

706. As discussed before, because Duan, Shin, Ryu, Koga, Wu, Yu, and Batchelder are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reading all of these references together, would have been motivated to combine Duan, Shin, Ryu, Koga, Wu, and/or Yu with Batchelder and vice versa.

707. Likewise, Nakano discloses: "The present invention relates generally to a cooling device for cooling a semiconductor element which generates a substantial quantity of heat and, in particular but not exclusively, to a compact, easy-to-handle and efficient cooling device for cooling such a semiconductor element by utilization of a change in phase between a liquid phase and a vapor phase of a refrigerant." Nakano, [0002]"Japanese Laid-Open Patent Publication No. 2000-208683 discloses a natural circulation type cooling device for cooling a heating element by utilization of a change in phase between a liquid phase and a vapor phase of a refrigerant, as shown in FIG. 1. The cooling device shown therein is provided with a refrigerant tank 20 for storing a liquid refrigerant, a radiator 22 for radiating heat from a vapor refrigerant, and a fan (not shown) for cooling the radiator 22. Because this cooling device is not provided with an inverter-controlled refrigerant pump, it controls the required cooling power merely by changing the number of revolutions of the fan depending on the amount of heat generated by the semiconductor element. Furthermore, Japanese Laid-Open Patent Publication No. 2000-208683 lacks any disclosure of an avoidance system in an abnormal situation. The present invention has been developed to overcome the above-described disadvantages. It is accordingly an objective of the present invention to provide a highly reliable semiconductor cooling device that is low in noise level and can conduct an appropriate control by changing the amount of circulation of refrigerant depending on the amount of heat generated by a semiconductor element." Nakano, [0004] – [0008] (paragraph breaks omitted).

708. Again, because Duan, Shin, Ryu, Koga, Wu, Yu, Batchelder, and Nakano are attempting to solve similar issues and each disclose or teach known techniques that can be used for

one another, a POSA, when reading all of these references together, would have been motivated to combine Duan, Shin, Ryu, Koga, Wu, Yu, and/or Batchelder with Nakano, and vice versa.

709. Likewise, Laing discloses: "The invention relates to a device for the local cooling or heating of an object by means of a liquid, comprising a circulation pump for the liquid. Devices of this type are used, for example, for the liquid cooling of microprocessors. In accordance with the invention, a device for the local cooling or heating of an object is provided which is of simple design since a thermal contact element for making thermal contact with the object is integrated in the circulation pump. Therefore, according to an embodiment of the invention, a thermal contact element such as a heat sink or heater which is brought into contact with the object is part of the circulation pump. In this way, it is possible to achieve a compact design of a liquid cooling device or heating device with effective cooling or heating of the object with which contact is made." Laing [0002-0005]. Laing further describes an embodiment that can be used for the liquid cooling of a processor: "An exemplary embodiment of a device according to the invention for the local cooling or heating of an object, which is denoted overall by 10 in FIG. 1, comprises a circulation pump 12, by means of which a fluid, such as water or other liquids, can be guided in a loop (FIG. 2) as a heat transfer medium. The heat transfer medium can be used as a cooling medium, in order to cool an object 14, such as for example an electronic component, such as a processor, which is positioned on a circuit board 16, for example. The heat transfer medium can also be used for heating an object. The circulation pump 12 comprises a housing 18. A feed line 20 is provided to allow a fluid to enter into the housing 18 by means of an opening 22 leading into a suction side of the

circulation pump 12. A discharge line 26 leads away from the housing 18 via an opening 24 from a pressure side (delivery side) of the circulation pump 12. The housing 18 may be pressed onto the object 14, for example by means of pressure-exerting clips (not shown). If the device is used as a cooling device, a cooling fluid, such as water, is supplied via the feed line 20, and heated cooling liquid which has been heated as a result of the cooling of the object 14, is discharged via the discharge line 26." Laing [0044 – 0047].

710. Again, because Duan, Shin, Ryu, Koga, Wu, Yu, Batchelder, Nakano and Laing are attempting to solve similar issues and each disclose or teach known techniques that can be used for one another, a POSA, when reading all of these references together, would have been motivated to combine Duan, Shin, Ryu, Koga, Wu, Yu, Batchelder and/or Nakano with Laing, and vice versa.

711. In sum, for the same reason as stated above, a person of ordinary skill in the art would have been motivated to combine the cited references in this report in a variety of combinations if reading these references together.

XIII. ENABLEMENT OF PRIOR ART REFERENCES

712. I am informed that to show obviousness, the defendant does not have a burden to show that the prior art is enabling. Nevertheless, in my opinion, each of the prior art references cited herein provide sufficient detail to enable a person of ordinary skill in the art to practice the asserted claims without undue experimentation, and when used in combination, would provide a POSA with a reasonable expectation that the combination

would be successful. That is, even if there were a requirement that each prior art reference be enabling, those references would satisfy such a requirement.

713. In my opinion, each of the Duan, Shin, Ryu, Koga, Wu, Yu, Batchelder, Nakano and Laing references enables a POSA to build and practice the disclosed cooling devices for their intended purposes. Each reference provides detailed drawings, figures, and/or schematics showing the structures of the disclosed cooling devices and their arrangements when used with the heat generating components that the cooling devices are supposed to cool. Each reference also provides detailed descriptions and/or drawings, figures, and/or schematics showing the inner workings of the disclosed cooling devices and how the cooling fluid flows through them. The references also all disclose or teach conventional components that would have been well known by a POSA, who would have been able to put them together in a known way with predictable results and a reasonable expectation of success.

714. When the cited references are combined or modified as a POSA would have been motivated to do, the combination or modification is also based on conventional or known methods that would have yielded predictable results and been reasonably expected to be successful by a POSA.

XIV. SECONDARY INDICIA OF NON-OBVIOUSNESS

715. I understand the following secondary factors, for example, can be considered to show non-obviousness.

- Commercial Success
- Long-Felt Need/Skepticism
- Copying

- Teaching Away
- Industry Praise

716. I have reviewed Asetek's response to CoolIT's Interrogatory No. 7, which asked Asetek to "[i]dentify all evidence upon which [Asetek] intends to rely to establish nonobviousness of the alleged inventions of the [asserted claims], including but not limited to an identification of any secondary considerations that [Asetek] contend[s] supports the nonobviousness of the alleged invention."

717. Asetek's Objections and Responses to Interrogatory No. 7 states that Asetek's commercial products embody the patented inventions and are coextensive with them. I am informed this statement is supposed to help establish a presumption of nexus (e.g., connections and/or causality) between the secondary factors (e.g., commercial success) with the purportedly inventive features.

718. I have been informed that for Asetek's products to be "co-extensive" with the asserted claims, the products cannot have any critical features that are unclaimed by the asserted claims. But I have been informed that all Asetek's relevant products include at least one feature unclaimed by any of the asserted claims, that the heat exchange interface of Asetek's relevant products is apparently made of copper. This feature was claimed twice in the asserted '355 patent (claims 4 and 10), in the previously asserted U.S. Patent No. 8,245,764 (the "'764 patent") (e.g., claim 8), and in Asetek's withdrawn motion to amend in the IPR2020-00522 proceeding. In my opinion, the feature of the heat exchanging interface being made of copper is critical in any product that supposedly practices the asserted claims. Without the heat conductivity of the copper used in the heat exchanging interface, the products would not function at all, or even if it does, the performance would

be so poor that there would be no place for such products to compete in the market. For instance, if the heat exchanging interface were made of plastic, it would suffer from very poor thermal performance. Other metals are problematic because they have a much lower thermal conductivity than copper (the thermal conductivity of copper is approximately 150 W/m-C larger than that of aluminum for example. Also, non-copper metals are more susceptible to corrosion and often require an added coating process. Thus, any claim by Asetek that this feature is insignificant is without justification and in any event is belied by the fact that Asetek has claimed or attempted to claim it several times in the same patent family. Thus, in my opinion, Asetek's products are not "co-extensive" with the scope of the asserted claims.

719. In any event, Asetek's response appears to take a shotgun approach to secondary considerations. In my opinion, all fail because no part of Asetek's response establishes the nexus with the asserted claims that I am informed is required by law. For example, Asetek touts "commercial success" based on its purported recognition and acceptance in the market, including but not limited to Asetek's initial public offering and its purported relationships with "OEM customer manufacturers" and "channel customers" But nowhere in the response Asetek has established any nexus or other connection between such touted "success" with the supposedly inventive features. Similarly, Asetek has not established its "RackCDU D2C^{TM}" practices any of the asserted claims. Thus, any partnership based on this product has nothing to do with the asserted claims in my opinion.

720. Regarding the purported long-felt need/the failure of others/recognition of a problem, the only touted feature by Asetek that purportedly supports this factor appears to be what is

known as the "all-in-one" or "AIO" feature. But as I repeatedly explained above, this feature has been repeatedly disclosed or taught in the prior art, and had been well-known in the industry prior to the asserted claims. To be sure, in my opinion, Asetek did not invent the all-in-one or AIO feature – because others, such as Batchelder, had already done so. Compare (Batchelder), 2:40-45 ("The primary objective of this invention is to provide a low cost high reliability heat exchange apparatus that incorporates a composite substrate containing flow channels and a heat transfer fluid, providing low thermal resistance cooling to high density heat sources.") (emphasis added) with asserted claims. Thus, in my opinion, Asetek's secondary considerations response fails. And in any event, Asetek's proffered evidence ultimately fails to overcome the strong evidence of obviousness set forth in this report.

721. Asetek's assertion of purported skepticism and unexpected results suffers from the same deficiency, as the response provides zero evidence how such alleged skepticism and unexpected result were linked in any way to the asserted claims. Asetek's claimed praise and industry recognition, copying of the invention by others, and requests for licenses of the asserted patents all lack any connection to the asserted claims.

722. I have also been informed that the asserted claims need to be novel to support secondary considerations. But Asetek's response does not even use the word "novel" or its synonyms to describe the asserted claims. In sum, I have been informed that the secondary factors can support nonobviousness only if such nexus is first established. But I have not found any evidence supporting the presumption of nexus in Asetek's response or proffered documents. Indeed, Asetek's response states that it "*will* establish the presumption of nexus in its favor via expert report(s) and testimony during the expert

phase of the case." Asetek effectively admits that such presumption of nexus has not been established. To the extent Asetek offers any expert opinions or testimonies or any other evidence to purportedly establish this presumption of nexus during the expert phase, I reserve my right to respond to such opinions, testimonies, and/or other evidence.

XV. INVALIDITY UNDER SECTION 112

723. Below I opine on why the asserted claims are patent ineligible and invalid under 35 U.S.C. § 112. My discussion below does not try to identify all recitations of a given term or phrase in each of the asserted claims. To the extent that I identify any instance of a term or limitation in a particular claim as rendering an asserted claim invalid under Section 112, my opinion is that every instance of such term or limitation in each of the asserted claims renders the claim invalid for the same reasons. I reserve the right to amend, supplement, or otherwise modify my patent-ineligibility and invalidity opinions under Section 112 to the extent Asetek proffers new, additional, or different constructions for terms used in the asserted claims.

724. Specifically, in my opinion, at least the following claim limitations from the asserted claims of the '601 patent do not satisfy requirements under Section 112 under the grounds explained further below:

- Claim 1: "a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber";
- Claim 1: "wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid

is collected along the perimeter and directed from the lower chamber through the second passage";

- Claim 6: "a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber";
- Claim 6: "wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber";
- Claim 12: "a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber";
- Claim 12: "wherein the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage."

725. In my opinion, at least claims 1, 6, 11, and 12 of the '601 patent are invalid for failure to comply with the written description and enablement requirements because they do not contain sufficient written description of the claimed inventions and do not provide a sufficiently enabling disclosure. I have been informed that the specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same. To satisfy the written description requirement, I understand a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can

reasonably conclude that the inventor had possession of the claimed invention at the time of filing the patent application. That is, to be enabling, the specification of a patent must teach a POSA how to make and use the full scope of the claimed invention without undue experimentation, as I understand it. In my opinion, the specification of the '601 patent does not adequately describe or enable the claimed inventions recited in claims 1, 6, 11, and 12, as explained below.

726. As to the limitation, "a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber," claims 1, 6, 11, and 12 lack written description support because the '601 patent specification fails to disclose any embodiment that supports all the limitations of the claims. Indeed, the embodiment in Figure 9, which in my opinion shows the only embodiment Asetek can rely on for the "substantially central" limitation, does not include any "heat exchanging interface" nor any remote "radiator." The embodiment in Figure 8, of which the internal structures are shown in Figure 7, fails to disclose the claimed "reservoir" with a pump chamber and thermal exchange chamber constituting a one-receptacle structure or "a first passage that fluidly couples the lower chamber to the upper chamber, wherein the first passage is substantially central to the lower chamber." Asetek will have to mix and match, for example, three different embodiments shown across Figures 8, 9, and 15 to string together the collection of independent limitations recited in each of the claims 1, 6, 11, and 12. But in my opinion, a POSA would have understood, based on the specification and the prosecution history of the '601 patent, that the device depicted in Figure 9 differs from the device depicted in Figure 15 at least because the embodiment in Figure 9 does not have a "heat exchanging interface 4" as that in Figure 15, which also

does not have any "first passage [15 that] is substantially central to the lower chamber" in Figure 9. Further, the embodiment in Figure 8 includes a remote radiator, which the embodiments in Figures 9 and 15 do not include. Thus, the embodiment in Figure 8 is also different from those in Figures 9 and 15.

727. In my opinion, there is no reason for how or why a POSA would have clearly recognized from the '601 patent that the inventor actually invented a device having the combination of features now claimed in claim 1, 6, 11, or 12, having both "a heat exchanging interface" and "a first passage [that] is substantially central to the lower chamber," as well as a remote "radiator." I understand that a description that merely renders the invention obvious does not satisfy the written description requirement." That is, I understand that claims are invalid for lack of a written description by combining various aspects of the disclosed embodiments that showed the claimed invention. Based on this understanding, it is my opinion that claims 1, 6, 11, and 12 lack written description support.

728. In my opinion, the specification also fails to support the limitation of "the lower chamber includes a plurality of parallel channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber where the cooling liquid is collected along the perimeter and directed from the lower chamber through the second passage." I have been informed that Asetek has asserted that this limitation is met by what is known in the industry as "microchannels," which I understand the parties have agreed means "channels with widths up to 1 millimeter." I believe the only support the '601 patent has for the limitation of "a plurality of parallel channels" is FIG. 9, which does not support "channels with widths up

to 1 millimeter." Indeed, a POSA would have understood the "parallel channels" in FIG. 9 to have widths larger than 1 millimeter. Thus, this limitation does not have written description support in my opinion. Further, a POSA would have understood that "microchannels" with widths up to 1 millimeter may require special techniques to manufacture, for which the '601 patent does not provide any information. For example, special tooling may be required to create the "fins" that form the microchannels with such small dimensions. [Kandlikar and Grande, "Evolution of Microchannel Flow Passages – Thermohydraulic Performance and Fabrication Technology," Heat Transfer Engineering, Vol. 24, (1), 2003 as just one example.] I have personally fabricated my own microchannels circa 2001 using specialized manufacturing techniques. Thus, at least because the '601 patent does not provide any embodiments with parallel channels with widths up to 1 millimeter or information on how to produce such channels, there is no enablement for a POSA to practice this limitation, "a plurality of parallel channels" if construed to include microchannels.

729. For the same reasons, at least the following claim limitations in the '354 patent do not satisfy requirements under Section 112, and thus any claim in the '354 patent containing one or more of the following limitations is invalid (e.g., claims 1, 8, and 15):

- "wherein the lower chamber includes a plurality of channels configured to split the flow of cooling liquid and direct the cooling liquid from the central region toward the perimeter of the lower chamber";
- "wherein the first passage directs the cooling liquid into the lower chamber where the cooling liquid splits and is directed along a plurality of channels from a central

region of the lower chamber outward, where the cooling liquid is collected and directed from the lower chamber through the second passage";

- "a first passage that fluidly couples the lower chamber to the upper chamber, where the first passage is substantially central to the lower chamber."

730. To be clear, the '354 patent and the '601 patent share the same specification. Thus, any discussion above regarding the '601 patent specification applies to the '354 patent specification.

731. Again, I have been informed that Asetek appears to interpret "a plurality of channels" in the '354 patent to cover microchannels. For the same reasons stated above regarding the "plurality of parallel channels" limitation in the '601 patent, Asetek's interpretation of the "plurality of channels" in the '354 patent renders any claim therein containing such limitation invalid.

732. Similarly, the "first passage is substantially central to the lower chamber" limitation suffers the same issues as those in the '601 patent concerning the "first passage is substantially central to the lower chamber" limitation. There is no single embodiment in the '354 patent to support any claim that contains the "first passage is substantially central to the lower chamber" limitation. Thus, any claim in the '354 patent containing this limitation is invalid.

XVI. INVALIDITY SUMMARY

733. Below is a table summarizing my invalidity analyses above:

Patent	Invalid Pursuant to §102	Invalid Pursuant to §103	Invalid Pursuant to §112
'362 patent		Claims 17, 19	

Patent	Invalid Pursuant to §102	Invalid Pursuant to §103	Invalid Pursuant to §112
’196 patent	Claims 1, 2, 13	Claims 1, 2, 13	
’601 patent		Claims 1, 6, 11, 12	Claims 1, 6, 11, 12
’354 patent		Claims 1, 8, 15	Claims 1, 8, 15
’355 patent	Claims 1, 2, 6	Claims 1, 2, 6	

XVII. VALUE COMPARISON BETWEEN COOLIT AND ASETEK PATENTS

A. Overview of CoolIT Patents

734. CoolIT has patented certain technologies related to the cooling of heat-generating devices and computer systems. In particular, the following patents are in the same family and cover the same technology.

a. U.S. Patent No. 8,746,330 (the "’330 patent")

b. U.S. Patent No. 9,057,567 (the "’567 patent")

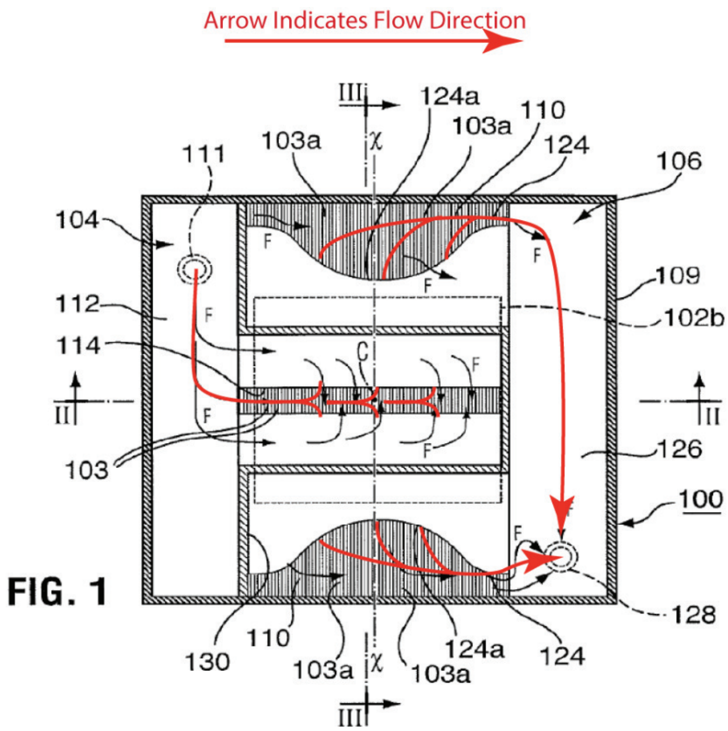
c. U.S. Patent No. 9,603,284 (the "’284 patent")

d. U.S. Patent No. 10,274,266 (the "’266 patent")

735. These patents deal with fluid heat exchangers that transfer heat from heat generating components, as I will now discuss. I refer to the four above-listed patents as the "’330 patent family".

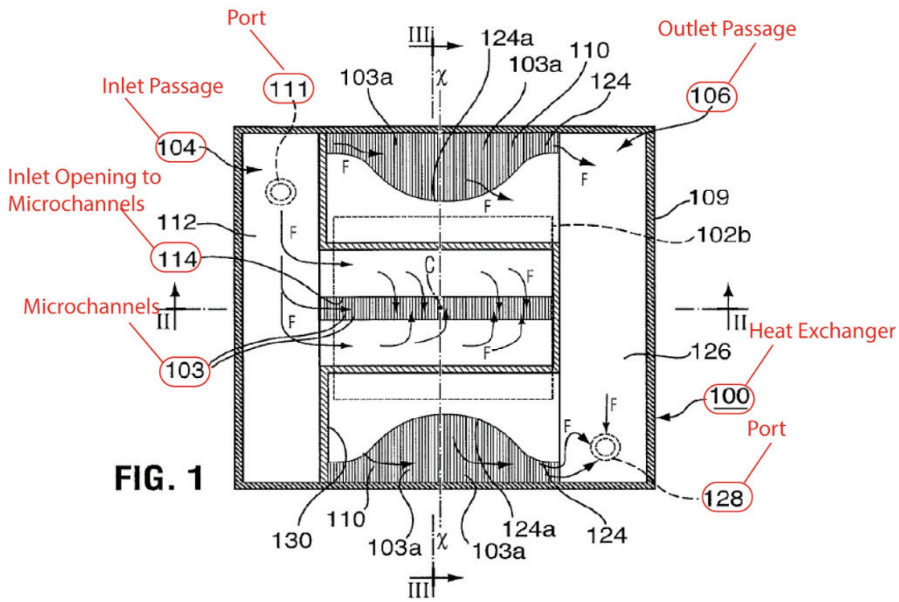
736. To aid in the discussion, Figure 1 from the ’330 patent is provided with annotations showing the flow direction for the depicted embodiment. As seen in the image, flow enters through inlet port 111 into inlet passage 104. The flow travels toward the center of the heat exchanger. There, the flow enters into the fin array through an inlet opening 114. Thereafter, the flow splits into two main parts (traveling upwards and downwards in the

figure). The flow passes across the heat-generating component, through the fin microchannels, and bounded by a shroud. The flow is able to exit the microchannels downstream of the shroud where it then flows to outlet passageway 106. There, the flow is collected and directed to the outlet port 128.



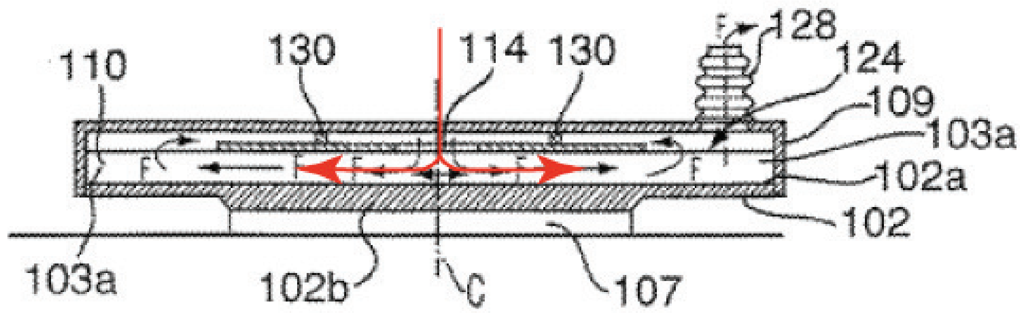
’330 patent, Figure 1

737. The following image identifies a number of the components of the fluid heat exchanger.



’330 patent, Figure 1

738. Figure 3, from the ’330 patent, shows a cross-sectional view with arrows indicating the flow direction. In the figure, the flow is directed toward the heat-generating device. The flow is bifurcated into two streams. Item 107 is the heat generating component and 102 is the heat spreader plate. Heat generated in item 107 travels upwards across the contact region (102b), and into the flow. The flow carries the heat away before the fluid is replenished by free, cool fluid.



’330 patent, Figure 3

739. The ’284 patent specification is identical to the ’330; the only relevant differences between the two patents are the claims.

740. The ’567 patent is also in the same family and accomplishes the same goal as the ’330 and ’284 patents. In fact, every figure in the ’330/’284 patents also appear in the ’567 patent. There are additional details provided, for example, in the following image. There, the fluid circuit is shown, with two manifolds, a number of parallel microchannels, as well as a liquid pump and a heat exchanger.

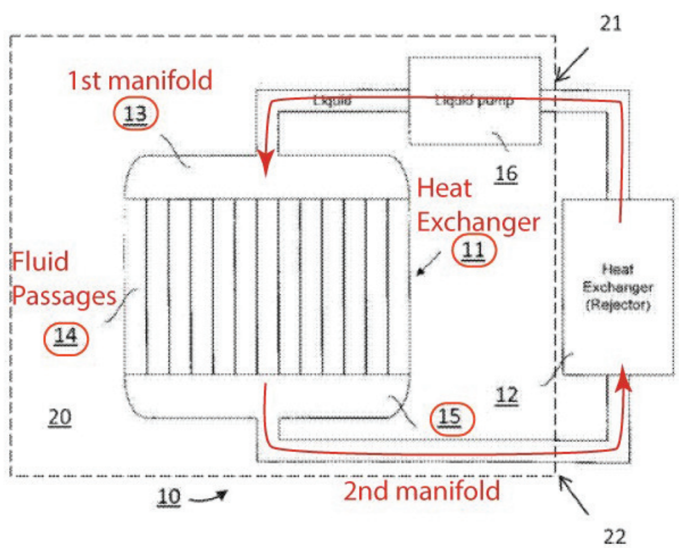


FIG. 1

’567 patent, Figure 1

741. The ’567 patent also provides additional information about the flow passages and geometry of the internal components.

742. The ’266 patent specification is identical to the ’567 specification; the only differences between these two patents are in the claim language.

743. All four of the CoolIT patents disclose a fluid heat exchange system that directs fluid to a heat-generating component in order to remove the heat. The heat is carried (advected) in the fluid and away from the heat-generating device.

B. Differences Between the Asserted Asetek Patents and the ’330 Patent Family

744. As seen from the above discussion, the ’330 patent family deals generally with fluid over a heat spreader. The heat spreader is topped with fins that serve as fluid microchannels and direct the flow in a bifurcated manner through the fin array. The ’330 patents also disclose a housing that confines the microchannels. A POSA would have understood that a microchannel has a hydraulic diameter less than 1 mm.

745. The accused patents (’362, ’601, and ’196 patents) have fundamental differences from the ’330 patent family. As clear from the accused patents, they claim an integrated cooling system with a heat exchanging interface, a reservoir, and a pump. The reservoir in the accused patents has an upper chamber and a lower chamber that are fluidly coupled. The accused patents also disclose a radiator that is fluidly connected to the system and allows heat to be removed from the working fluid.

746. There are clear differences between the ’330 patent family and the accused patents. In particular, the ’330 patent discloses the simultaneous use of microchannels and flow

bifurcation in a way that both improves thermal performance but also increases pumping performance (pressure losses). The asserted Asetek patents are silent on both of these disclosures; they neither mention microchannels nor a flow bifurcation.

747. One novelty of the ’330 patent family is that it provides a solution to two mutually opposing physical processes. On the one hand, microchannels are known to provide excellent heat transfer performance (increasing the surface area for heat transfer and improvements to the convective heat transfer coefficient). But the bane of microchannels is that the pumping performance pressure loss is large.

748. The ’330 patent family also discloses a flow distribution to and from the microchannels using headers/manifolds or equivalent flow distribution structures. Flow distribution to the multiple microchannels promotes uniform cooling and improved hydraulic (pressure) performance.

749. A POSA would have known that balancing the demands for thermal performance and pumping power is required for an efficient system to cool heat-generating devices and CPUs. In fact, POSAs commonly use a performance metric which is the ratio of the thermal performance to the hydraulic (pressure) performance.

C. Features that Drive Demand and Benefits of the CoolIT patents

750. A POSA, working on thermal management of heat-generating components such as computer processors or other electrical components in computer systems, would know how to make decisions about techniques to cool those components. There are a number of features and issues that affect the demand for such products. The following is a list of

some of the issues that a POSA would consider. While the list is not intended to be exhaustive, it includes some of the most important key determinants.

751. **Thermal Resistance and Thermal Performance:** Thermal resistance is a description of the heat transfer capability of a heat-removal device. Devices with a small thermal resistance are able to transfer heat with very little temperature differences. Contrariwise, a device with a large thermal resistance has difficulty in transferring heat. In order to maintain low temperatures in a heat generating device (for example, a CPU), a POSA would prioritize devices that have a low thermal resistance over devices that have a high thermal resistance. This feature is expressly mentioned, for example, in the following passages.

> Despite the existence of many previously proposed fluid heat exchange systems, there remains a need for heat exchange systems configured to provide improved thermal performance. As well, there remains a need for systems configured for existing and developing small form factors, and more particularly. For example, there remains a need for low-profile heat exchange assemblies (e.g., integrated heat sink and pump assemblies) having a vertical component height of about 27 mm, such as between about 24 mm to about 27.5 mm, or less. There also remains a need for integrated components and systems having fewer fluid connections. In addition, there is a need for low-pressure-loss flow transitions in integrated heat exchange components.

'567 patent, lines 29-41 (highlights added)

SUMMARY

The innovations disclosed herein overcome many problems in the prior art and address the aforementioned, as well as other, needs. The innovations disclosed herein pertain generally to fluid heat exchange systems and more particularly, but not exclusively, to approaches for integrating components in such systems. For example, some innovations are directed to low-profile pump housings. Other innovations are directed to heat sink designs that deliver improved heat-transfer and/or pressure-loss performance. And other innovations are directed to approaches for eliminating system components while retaining their respective functions.

’567 patent, lines 43-55 (highlights added)

752. **Overclocking:** Heat-generating computer components such as CPUs have a clock speed which is a measure of the number of operations the CPU can perform in a fixed amount of time. Since CPU operations require electricity, the faster a CPU, the more electricity (and consequently the more heat). Some computer users attempt overclocking which is shorthand for operating a CPU with a higher frequency of operation than their default operation. Overclocked CPUs are faster and process more information than they otherwise could. High-demand applications (image and video processing, gaming, computational simulations, etc.) are amendable to overclocking. However, overclocking results in an increase in unwanted heat generation. Consequently, users who intend to overclock their CPUs often run into overheating problems because the default heat removal system may be inadequate for an overclocked system. Such a situation would motivate a POSA to use a heat removal system such as that articulated in the ’330 patent family.

753. **Noise Reduction:** Regardless of the thermal system, the ultimate destination of heat is to the ambient environment (usually to the room air). As such, heat exchange systems often include a radiator; the radiator in turn typically utilizes a fan for directing air over the radiator. Noise is generated in electronic computer systems; mainly through the liquid pump and the just mentioned air fan. The more efficient a heat exchange system, the less sound is generated. Consequently, a POSA wishing to reduce unwanted sound would be motivated to use an efficient cooling system (such as that articulated by the ’330 patent family).

754. **Pressure:** Any fluid flow system will exhibit a pressure variation in the flow. In fact, pressure causes fluid flow (fluid prefers to flow from high to low pressure). As the fluid flows through the heat exchange system, the positive pressure generated by the pump is spent overcoming pressure losses. There is a balance between the pressure gain incurred by the pump, and the pressure losses associated with the flow. A POSA would have been motivated to reduce pressure losses within a heat exchange system. In fact, an optimal system would be one with a minimal pressure loss. The ’330 patent family cleverly devises a flow that minimizes the pressure. Splitting the fluid flow into two streams, using a multitude of parallel microchannels, and introducing the fluid at the center of the heat-generation region all contribute to pressure improvements. These considerations are articulated in the patents, for example, in the following passage.

> Despite the existence of many previously proposed fluid heat exchange systems, there remains a need for heat exchange systems configured to provide improved thermal performance. As well, there remains a need for systems configured for existing and developing small form factors, and more particularly. For example, there remains a need for low-profile heat exchange assemblies (e.g., integrated heat sink and pump assemblies) having a vertical component height of about 27 mm, such as between about 24 mm to about 27.5 mm, or less. There also remains a need for integrated components and systems having fewer fluid connections. In addition, there is a need for low-pressure-loss flow transitions in integrated heat exchange components.

’567 patent, lines 29-41 (highlights added)

755. **Compactness:** A POSA would have known that many heat-exchange applications, especially those associated with cooling electronic systems, have size limitations. Consequently, a POSA would have been motivated to use a heat exchange system that is compact and has a low-profile design. The ’330 patent family offers just such a compact heat exchange solution. The small size is discussed in the patents, for example in the following passages.

> Despite the existence of many previously proposed fluid heat exchange systems, there remains a need for heat exchange systems configured to provide improved thermal performance. As well, there remains a need for systems configured for existing and developing small form factors, and more particularly. For example, there remains a need for low-profile heat exchange assemblies (e.g., integrated heat sink and pump assemblies) having a vertical component height of about 27 mm, such as between about 24 mm to about 27.5 mm, or less. There also remains a need for integrated components and systems having fewer fluid connections. In addition, there is a need for low-pressure-loss flow transitions in integrated heat exchange components.

’567 patent, lines 29-41 (highlights added)

SUMMARY

The innovations disclosed herein overcome many problems in the prior art and address the aforementioned, as well as other, needs. The innovations disclosed herein pertain generally to fluid heat exchange systems and more particularly, but not exclusively, to approaches for integrating components in such systems. For example, some innovations are directed to low-profile pump housings. Other innovations are directed to heat sink designs that deliver improved heat-transfer and/or pressure-loss performance. And other innovations are directed to approaches for eliminating system components while retaining their respective functions.

’567 patent, lines 43-55 (highlights added)

756. **Reduced fluid connections and simplified design:** A POSA would have been motivated to select a cooling system that possesses few fluid connections and a simplified design. Fluid connections are areas where leaks can occur and where fluid-tight connections must be attained. This feature is articulated, for example, in the following passages.

Despite the existence of many previously proposed fluid heat exchange systems, there remains a need for heat exchange systems configured to provide improved thermal performance. As well, there remains a need for systems configured for existing and developing small form factors, and more particularly. For example, there remains a need for low-profile heat exchange assemblies (e.g., integrated heat sink and pump assemblies) having a vertical component height of about 27 mm, such as between about 24 mm to about 27.5 mm, or less. There also remains a need for integrated components and systems having fewer fluid connections. In addition, there is a need for low-pressure-loss flow transitions in integrated heat exchange components.

’567 patent, lines 29-41 (highlights added)

SUMMARY

The innovations disclosed herein overcome many problems in the prior art and address the aforementioned, as well as other, needs. The innovations disclosed herein pertain generally to fluid heat exchange systems and more particularly, but not exclusively, to approaches for integrating components in such systems. For example, some innovations are directed to low-profile pump housings. Other innovations are directed to heat sink designs that deliver improved heat-transfer and/or pressure-loss performance. And other innovations are directed to approaches for eliminating system components while retaining their respective functions.

’567 patent, lines 43-55 (highlights added)

757. **Integrated design/reliability:** A POSA would have been motivated to select a cooling methodology that has an integrated design wherein multiple parts are assembled together. Integrated designs improve reliability and simplifies replacement in the event of failure. The ’330 patent family discloses an integrated cooling system, as indicate by the following passages.

Despite the existence of many previously proposed fluid heat exchange systems, there remains a need for heat exchange systems configured to provide improved thermal performance. As well, there remains a need for systems configured for existing and developing small form factors, and more particularly. For example, there remains a need for low-profile heat exchange assemblies (e.g., integrated heat sink and pump assemblies) having a vertical component height of about 27 mm, such as between about 24 mm to about 27.5 mm, or less. There also remains a need for integrated components and systems having fewer fluid connections. In addition, there is a need for low-pressure-loss flow transitions in integrated heat exchange components.

’567 patent, lines 29-41 (highlights added)

SUMMARY

The innovations disclosed herein overcome many problems in the prior art and address the aforementioned, as well as other, needs. The innovations disclosed herein pertain generally to fluid heat exchange systems and more particularly, but not exclusively, to approaches for integrating components in such systems. For example, some innovations are directed to low-profile pump housings. Other innovations are directed to heat sink designs that deliver improved heat-transfer and/or pressure-loss performance. And other innovations are directed to approaches for eliminating system components while retaining their respective functions.

’567 patent, lines 43-55 (highlights added)

758. **Uniform Cooling:** A POSA would desire a methodology that can provide uniform cooling to a heat-generating component. Heat is generated within the heat-generating component and consequently, the temperature of the heat-generating component tends to rise – until the heat being generated is balanced by the heat loss from the exterior of the heat-generating device. It is advantageous to ensure that heat loss from the exterior of the heat-generating device is uniform so that the temperatures of the heat-generating device are also uniform. Failure to extract heat uniformly from the heat-generating device inevitably leads to a spatial temperature variation (thermal non-uniformity). Consequently, hot spots and cold spots inevitably develop which are a risk to the heat-generating component. The ’330 patent family accomplishes uniform cooling by introducing the cooling fluid into the center region of the heat-generating component; thereafter the fluid bifurcates into two streams that are directed away from the center and toward the perimeter of the heat-generating component. The ’330 patent family also provides a means to introduce/remove fluid into/from a multitude of microchannels, with the aid of a manifold/plenum or equivalent.

759. **Cost:** A POSA would seek a cooling methodology that reduces the cost of the system; provided the thermal/fluid performance of the methodology is sufficient to adequately remove heat and maintain sufficiently low temperatures in the heat-generating component.

D. The Asetek Gen3 and Gen 4 Liquid Cooling Systems

760. Asetek has developed multiple generations of its liquid cooling systems. The third generation Asetek liquid cooling system incorporated microchannels. The Gen3 version utilizes a traditional end-to-end flow path for the cooling. That is, the coolant is introduced at one end of the system into microchannels. The fluid passages carry fluid past the heat generating component where heat is transferred to the fluid. At the outlet of the microchannels, the fluid is directed to a radiator where the thermal energy is removed from the fluid.

761. In contrast, the GEN 4 system copies the center-flow of the ’330 patent family such that coolant is introduced to the center region of the heat-generating component. The fluid then bifurcates and flows outward until it is collected and directed to an external radiator for heat removal.

762. Asetek’s website confirms the flow bifurcator, for example in the following text which is found at: https://www.asetek.com/newsroom/press-releases/2012-press-releases/asetek-releases-fourth-generation-of-patented-all-in-one-liquid-coolers?referer=0

763. As noted from the above-referenced Asetek documentation, the new design improves the thermal performance, reduces noise, and overclocking

> "Asetek Gen4 products combine the micro-channel cold plate technology from our Gen3 products with the center inlet, split-flow design of Asetek's WaterChill Antarctica architecture cold plates," said André Sloth Eriksen, Founder and CEO of Asetek. "The split-flow Antarctica architecture was state-of-the art when we introduced it back in 2004 and by combining it with newer micro-channel technology, we are pushing the theoretical performance limits of copper cold plate design."
>
> The new Gen4 cold plate is paired with a completely redesigned pump that provides better coldplate efficiency. Asetek's new pump produces higher pressure and distributes coolant more optimally. Gen4 products provide 20% less thermal resistance than the previous generation, resulting in lower CPU core temperatures. This provides computer enthusiasts the highest thermal headroom for overclocking at the lowest noise possible.

764. As acknowledged by Asetek's own documentation, the change from Gen3 to Gen4 and the incorporation of a central flow arrangement led to a reduction of noise, improved thermal performance, and an ability to overclock CPUs. Clearly, these attributes can be attributed to Asetek's move from Gen 3 (non-infringing) to Gen 4 (infringing) products.

765. I have inspected a physical copy of the Gen4 Asetek system and confirm it is a central flow arrangement, as discussed above. I am not aware of relevant factors that would indicate non-obviousness of the asserted patents.

Date: November 3, 2021

John Abraham

Dr. John Abraham
University of St. Thomas
School of Engineering
2115 Summit Ave
St. Paul, MN 55105-1079

APPENDIX A

CURRICULUM VITAE

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

SUMMARY

Thermal science expert with experience in all aspects of heat transfer and fluid mechanics. Produced approximately 400 publications, books, book chapters, conference presentations, and patents in areas including biological heat transfer and fluid flow, biomedical device design, energy, burn injuries, climate change, fundamental heat transfer and fluid mechanics, and manufacturing processes. Author of approximately 350 popular press articles and has been in more than 80 radio and television appearances

APPOINTMENTS

University of St. Thomas, St Paul, MN

Professor	**2013-Present**
Associate Professor	**2008-2013**
Assistant Professor	**2002-2008**

EDUCATION

University of Minnesota - Twin Cities, Minneapolis, MN

Ph.D., Mechanical Engineering (Thermal Sciences)	**2002**
M.S., Mechanical Engineering, GPA 3.96/4.00	**1999**
B.S., Mechanical Engineering, GPA 4.00/4.00, **Minor**: Mathematics	**1997**

PREVIOUS TEACHING EXPERIENCE

Adjunct Faculty, *University of St. Thomas, St Paul, MN*	**2000-2002**
Graduate Teaching Fellow, *University of Minnesota, Minneapolis, MN*	**2001-2002**
Teaching Assistant, *University of Minnesota, Minneapolis, MN*	**1997-2001**
Tutor, *University of Minnesota, Minneapolis, MN*	**1993-1997**

HONORS/AWARDS

- Journal of Atmospheric and Oceanic Technology, Editor award, (2020).
- National Center for Science Education Friend of the Planet Award (2016)
- University of St. Thomas Professor of the Year (2016)
- USA Green Deal of the Year business excellence award (2013)
- Composites Sustainability Award, American Composites Manufacturers Association Award for Composite Excellence, (2013)
- Nominated, George Mason University, Center for Climate Change Communication, Climate Change Communicator of the Year (2011)
- University of St. Thomas John Ireland Award (2009)
- University of St. Thomas Distinguished Educator Award (2008)
- University of St. Thomas Engineering Professor of the Year (2005)
- Graduate Teaching Fellowship (2001/2002)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (1999/2000)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2000/2001)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2001/2002)

4232 29th Ave.
Minneapolis, MN 55406
John P. Abraham
jpabraham@stthomas.edu
612-963-2169

- Mechanical Engineering Teaching Assistant of the Year, Mechanical Engineering Department, University of Minnesota (1998/1999)
- Minnesota Professional Engineers Foundation Orion Buan Memorial Scholarship (1996)
- Walter and Margaret Pierce Endowment Fund Scholarship (1996)
- National Space Grant Consortium Scholarship (1996)
- Frank Louk Scholarship (1996)
- Citizens' Scholarship (1992-1995)
- Alfred O. Neir Scholarship (1994)
- Dean's List (1993-1997)

OTHER POSITIONS

Climate Blogger – Guardian Newspaper **2013-2021**

PUBLICATIONS

(16 edited works, 3 books, 17 book chapters, 230 journal publications, 143 presentations,13 granted patents, 5 patent applications, 2 granted trademarks)

TOP PUBLICATIONS BY ALTMETRIC

L. Cheng, J.P. Abrahm, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reserghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit Record High in 2020, *Advances in Atmsopheric Sciences,* Vol. 38, pp. 523-530, 2021. **Altmetric score = 1, to413p 1% in all journals, August 2021.**

G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change,* Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 726, top 1%, July 2021.**

J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 392, top 1%, July, 2021.**

L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **(This paper was in the top 100 of all published scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021).**

L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues record global warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021.**

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

Editing Activities

1. Editor, Advances in Heat Transfer, Vol. 53, Elsevier, (forthcoming, 2021).
2. Editor, Advances in Heat Transfer, Vol. 52, Elsevier, 2020.
3. Editor, Advances in Heat Transfer, Vol. 51, Elsevier, 2019.
4. Editor, Advances in Heat Transfer, Vol. 50, Elsevier, 2018.
5. Editor, Advances in Heat Transfer, Vol. 49, Elsevier, 2017.
6. Editor, Advances in Heat Transfer, Vol. 48, Elsevier, 2016.
7. Editor, Advances in Heat Transfer, Vol. 47, Elsevier, 2015.
8. Editor, Advances in Heat Transfer, Vol. 46, Elsevier, 2014.
9. Editor, Advances in Numerical Heat Transfer Vol. 5: Numerical Models of Heat Exchangers, Taylor and Francis, New York, 2017.
10. Editor, Small-Scale Wind Power – Design, Analysis, and Economic Impacts, Momentum Press, 2014.
11. Editor, Advances in Heat Transfer, Vol. 45, Elsevier, 2013.
12. Editor, Advances in Heat Transfer, Vol. 44, Elsevier, 2012.
13. Editor, Advances in Numerical Heat Transfer Vol. 4: Nanoscale Heat Transfer and Fluid Flow, Taylor and Francis, New York, 2012.
14. Guest Editor, Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Biological Models and Equations, Taylor and Francis, New York, 2009.
15. Guest Editor, Special Edition of the International Journal of Heat and Mass Transfer: Bioheat and Biofluid Flow, Elsevier, Vol. 51, 23-24, November, 2008.
16. Assistant Editor, Handbook of Numerical Heat Transfer, 2nd Ed. Editors: Sparrow, Minkowycz, and Murthy, John-Wiley & Sons, Inc., New York, 2006.

Editorial Board Member

1. International Society of Cardiovascular Translational Research, 2020-present
2. Energies, Thermal Management, 2019-present
3. Cardiovascular Revascularization Medicine, 2018-present
4. Stem Cell Biology and Transplantation, 2015-present
5. Associate Editor, National Center for Science Education, Climate Science, 2012-present
6. International Journal of Mechanics and Energy, 2012-present
7. Open Mechanical Engineering Journal, 2007-present
8. Open Mechanical Engineering Reviews, 2007-present
9. Open Mechanical Engineering Letters, 2007-present
10. Open Medical Devices Journal, 2008-present
11. Creative Engineering Journal, 2009-present
12. ISRN Applied Mathematics, 2011-present
13. International Journal of Sustainable Energy, 2012 - present
14. International Journal of Materials, Methods, and Technologies, 2012- present

Books

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

1. J.P. Abraham and B.D. Plourde, Small-Scale Wind Power – Design, Analysis, and Environmental Impacts, Momentum Press, 2014.

2. J.P. Abraham, P.S. Ellis, M.C. MacCracken, and G.M. Woodwell, Climate controversy 2013. New York, NY: AuthorHouse, 2013.

3. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R.Ramazani-Rend, and J.C.K. Tong, All Fluid-Flow-Regimes Simulation Model for Internal Flows, Nova Science Publishers, Inc., Hauppauge, NY, 2011.

Book Chapters

1. F. Salamsi and J.P. Abraham, Effect of Inclination of Cutoff Wall Beneath Gravity Dams on Uplift Force, in *Novel Perspectives of Engineering Research*, 2021.

2. J.P. Abraham, S. Bhattacharya, L. Cheng, and J.M. Gorman, A Brief History of and Introduction to Computational Fluid Dynamics, in *Computational Fluid Dynamics*, edited by: Suvanjan Bhattacharya, published by IntechOpen, (forthcoming 2021).

3. F. Salamsi and J.P. Abraham, The Method of Characteristics Applied to the Sensitivity Analysis for Water Hammer Problems, *New Approaches in Engineering Research*, B.P. International, Vol. 9, pp. 50-63, 2021.

4. J. Gorman, S. Bhattacharya, J.P. Abraham,, L. Cheng, Turbulence Models Commonly used in CFD, in: *Computational Fluid Dynamics*, edited by: Suvanjan Bhattacharya, published by IntechOpen, (forthcoming 2021).

5. B.D. Plourde, J. Kilonzo, J. Kiplagat, J.P Abraham, and L. Cheng, From Sunlight to Drinking Water – The Design and Validation of a Solar-Pasteurization System, Published in *Handbook of Research on Heat Transfer*, edited by S. Bhattacharyya and V. Goel, (in press).

6. J.M. Gorman, M. Regnier, and J.P. Abraham, Heat Exchange Between the Human Body and the Environment – A Comprehensive, Multi-Scale Numerical Simulation, in: *Advances in Heat Transfer* Vol. 52, 2020.

7. L.E. Olsen, J.P. Abraham, L.J. Cheng, J.M. Gorman, E.M. Sparrow, Summary of Forced-Convection Fluid Flow and Heat Transfer for Square Cylinders of Different Aspect Ratios Ranging from the Cube to a Two-Dimensional Cylinder, in: *Advances in Heat Transfer* Vol. 51, pp. 351-457, 2019.

8. E.M. Sparrow, J.M. Gorman, A. Ghoash, J.P. Abraham, Enhancement of Jet Impingement Heat Transfer by Means of Jet Axis Switching, in: *Advances in Heat Transfer,* Vol. 50, 2018.

9. E.M. Sparrow, J.M. Gorman, J.P. Abraham, W.J. Minkowycz, Validation of Turbulence Models for Numerical Simulation of Fluid Flow and Convective Heat Transfer, in: *Advances in Heat Transfer*, Vol. 49, 397-421, 2017.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

10. J.M. Gorman, E.M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Exchangers and Their Fan/Blower Partners Modeled as a Single Interacting System by Numerical Simulation, in: *Advances in Numerical Heat Transfer Vol. 5,* Taylor and Francis, New York, 2017.

11. J.P. Abraham, B.D. Plourde, L.J. Vallez, B.B. Nelson-Cheeseman, J.R. Stark, J.M. Gorman, E.M. Sparrow, Skin Burn, in: *Theory and Application of Heat Transfer in Humans*, edited by Devashish Shrivastava, Wiley, June 2018.

12. M.W. Dewhirst, J.P. Abraham, B.L. Viglianti, Evolution of Thermal Dosimetry for Application of Hyperthermia Treatment to Cancer, in: *Advances in Heat Transfer*, Vol. 47, 397-421, 2015.

13. B.D. Plourde, E.D. Taylor, P.O. Okaka, and J.P. Abraham, Financial and Implementation Considerations for Small-Scale Wind Power, in: *Small-Scale Wind Power – Design, Analysis*, *and Economic Impacts*, Momentum Press, 2014.

14. B.D. Plourde, E.D. Taylor, W.J. Minkowycz, and J.P. Abraham, Introduction to Small-Scale Wind Power, in: *Small-Scale Wind Power – Design, Analysis, and Economic Impacts*, Momentum Press, 2014.

15. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R. Ramazani-Rend, and J.C.K. Tong, Modeling Internal Flows by an Extended Menter Transition Model, in: *Turbulence: Theory, Types, and Simulation*, Nova Publishers, New York, 2011.

16. S. Ramadhyani, J.P. Abraham, and E.M. Sparrow, A Mathematical Model to Predict Tissue Temperatures and Necrosis During Microwave Thermal Ablation of the Prostate, in: *Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Bioheat Models and Equations*, Taylor and Francis, New York, 2009.

17. J.P. Abraham and E.M. Sparrow, Heat-Transfer and Temperature Results for a Moving Sheet Situated in a Moving Fluid, in: *Heat-Transfer Calculations, 2nd ed.,* editor, Myer Kutz, McGraw-Hill, 2005.

Publications

2021

1. Y. Liu, L. Cheng, Y. Pan, J.P. Abraham, B. Zhang, J. Zhu, and J. Song, Climatological seasonal variation of the upper ocean salinity, *International Journal of Climatology*, (submitted)

2. F. Salamsi, J.P. Abraham, and A. Salmasi, Effect of Stepped Spillways on Increasing Dissolved Oxygen in Water, an Experimental Study, *Journal of Environmental Management*, (*accepted*).

3. C. Garcia-Soto, L. Cheng, L. Caeser, E.B. Jewett, A. Cheripka, I.G. Rigor, A. Cabellero, S. Chiba, J.C. Baez, T. Zielinski, and J.P. Abraham, An Overview of

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

Ocean Ckunate Chgange Indicators: Sea Surface Temperature, Ocean Heat Content, Ocean pH, Dissolved Oxygen Concentration, Artic Ice Extent, Thickness, and Volume, *Frontiers in Marine Science, Global Ocean and Future Ocean,* (accepted).

4. J.P. Abraham, T. Wei, and Y. Wang, Layered Structure of Turbulent Natural Convection Over a Vertical Flat Plate, *International Journal of Heat and Mass Transfer*, (accepted).

5. F. Salamsi, F. Nahrain, J.P. Abraham, and A.T. Aghdam, Prediction of Discharge Coeefficients for Broad-Crested Weirs Using Expert Systems, *Journal of Hydraulic Engineering*, (accepted).

6. F. Salamsi and J.P. Abraham, Closure to "Expert System for Determining Discharge Coefficients for Inclined Slide Gates Using Genetic Programming", *Journal of Irrigation and Drainage Engineering,* Vol. 147, paper no. 07021018, 2021.

7. L. Olsen, S. Bhattacharyya, L. Cheng, W. Minkowycz, and J. Abraham, Heat Transfer Enhancement for Internal Flows with a Centrally Located Circular Obstruction and the Impact of Buoyancy, *Heat Transfer Engineering* (accepted).

8. F. Salamsi and J.P. Abraham, Closure to "Discharge Coefficients for Rectangular Broad-Crested Gabion Weirs: An Experimental Study", *Journal of Irrigation and Drainage Engineering*, (accepted).

9. R. Daneshfaraz, E. Aminvash. S. Di Francesco, A. Najibi, and J.P. Abraham, Three-Dimensional Study of the Effect of Block Roughness Geometry on Inclined Drop, *Journal of Numerical Methods in Civil Engineering*, Vol. 6, pp. 1-9.

10. J.C.K. Tong, J.M.Y. Tse, J.P. Abraham, P.J. Jones, Correlation between simulations and measuremants of an eco-house design for Mongolia, *Journal of Building Engineering*, Vol. 42, no. 10, paper no. 102774, 2021. DOI:10.1016/j.jobe.2021.102774.

11. A. Armanous, A. Negm, A. Javadi, J.P. Abraham, and T. Gado, J.P. Abraham, Impact of Inclined Double-Cutoff Walls Under Hydraulic Structures on Uplift Forces, Seepage Discharge, and Exit Hydraulic Gradient, *Ain Shams Engineering Journal* (in press). DOI: 10.1016/j.asej.2021.06.017.

12. R. Daneshfaraz, M. Abam, M. Heidarpour, S. Abbasi, M. Seifollahi, and J.P. Abraham, The Impact of Cables on Local Scouring of Bridge Piers Using Experimental Study and ANN, ANFIS Algorithms, *Water Supply* (in press). DOI:10.2166/ws2021.215

13. R. Norouzi, P. Sihag, R. Daneshfaraz, J.P Abraham, and V. Hasanna, Predicting Relative Energy Dissipation for Vertical Drops Equipped with a Horizontal Screen Using Soft Computing Techniques, *Water Supply*, (in press). DOI: 10.2166/ws.2021.193.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

14. R. Daneshfaraz, E. Aminvash, A. Ghaderi, A. Kuriqi, and J.P. Abraham, Three-Dimensional Investigation of Hydraulic Properties of Vertical Drop in the Presence of *Step and Grid Dissipators, Symmetry, Computer Engineering Science and Symmetry Turbulence and Multiphase Flows*, Vol. 13, paper no. 895.

15. T. Wei, Y. Wang, and J.P. Abraham, Integral Properties of Turbulent Natural Convection over a Vertical Flat Plate, *International Communications in Heat and Mass Transfer*, Vol. 125, paper 105286, 2021.

16. R. Daneshfaraz, E. Aminvash, A. Ghaderi, M. Bagherzadeh, J.P. Abraham, SVM Performance in Predicting the Effect of Horizontal Screens on Vertical Hydraulic Performance of a Vertical Drop, *Applied Sciences*, Vol. 11, no. 9, paper no. 4238, 2021. DOI: 10.3390/app11094238.

17. R. Daneshfaraz, S. Sadeghfam, V. Hasanniya, J.P. Abraham, and R. Norouzi, Experimental Investigation on Hydraulic Efficency of Vertical Droip Equipped with Vertical Screens, *Teknit Dergi*, Vol. 33, no. 5, (in press), 2022. DOI: 10.18400/tekderg.755938.

18. F.Salamsi, M. Nouri, P. Sihag, and J.P. Abraham, Application of SVM, ANN, GRNN, RF, GP, and RT Models for Predicting Discharge Coefficients of Obblique Sluice Gates Using Experimental Data, *Water Supply*, Vol. 21, pp. 232-248, 2021.

19. A. Aghdam, F. Salamsi, J.P. Abraham, and H. Arvanaghi, Effect of Drain Pipes on Uplift Force ad Exit Hydraulic Gradient and the/ Design of Gravity Dams Ysing the Finiate Element Method, *Geotechnical and Geological Engineering*, Vol. 39, pp. 3383-3399, 2021.

20. Z. Tan,F. Reseghetti, J.P. Abraham R. Cowley, K. Chen, J. Zhu, B. Zhang, and L. Cheng, Examining the Influence of Recording System on the Pure Temperature Error in XBT Data, *Journal of Atmospheric and Oceanic Technology,* Vol. 38, pp . 759-776, 2021.

21. J.M. Gorman, W. Tan, and J.P. Abraham, Numerical Simulation of Microwave Ablation in the Human Liver, Heat Transfer in Biomedical Applications, edited by A. Andreozzi, M. Iasiello, V. Timochenko, and K. Vafai, published in *Processes*, (submitted).

22. R. Daneshfaraz, V. Hasannia, R. Norouzi, P. Sihag, S. Sadeghfam, and J.P. Abraham, Investigating the Effect of Horizontal Screen on Hydraulic Parameters of a Vertical Drop, Iranian Journal of Science and Technology, *Transactions of Civil Engineering*, (in press), 2021.

23. L. Cheng, J.P. Abrahm, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reserghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

Record High in 2020, *Advances in Atmsopheric Sciences,* Vol. 38, pp. 523-530, 2021. **Altmetric score = 1057, top 1%, January 2021.**

24. A. Ghaderi, R. Daneshfaraz, S. Abbasi, and J.P. Abraham, Numerical Analysis of the Hydraulic Characteristics of Modified Labyrinth Weirs, *International Journal of Energy and Water Resources*, Vol. 4, pp. 425-436, 2020.

25. M. Nouri, P. Sihag, F. Salamsi, and J.P. Abraham, Prediction of Homogeneous Earthen Slope Safety Factors Using the Forest and Tree Based Modeling, *Geotechnical and Geological Engineering*, Vol. 35, paper no. 04020148.

26. F. Salamsi, B. Nourani, J.P. Abraham, and R. Nouzi, Numerical Investigation of Relief Well Performance for Decreasing Uplift Pressure Under Embankment Dams, *International Jounral of Environmental Science and Technology*, doi: 10.1007/s13762-020-03030-2.

27. R. Daneshfaraz, M. Bagherzadeh, R. Esmaeeli, R. Norouzi, and J.P. Abraham, Study of the Performance of Support Vector Machine for Predicting Vertical Drop Hydraulic Parameters in the Presence of Dual Horizontal Screens, *Water Supply,* Vol. 21, pp. 217-231, 2021.

28. F. Salamsi, J.P. Abraham, Prediction of Discharge Coefficients for Sluice Gates Equipped With Different Geometry Sills Under the Gate Using Multiple Non Linear Regression (MNLR), *Journal of Hydrology*, doi:10.1016/j.jhydrol.2020.125728.

29. F. Salamsi, N. Sabahi, and J. P. Abraham, Discharge Coefficients for Rectangular Broad Crested Gabion Weirs: An Expertimental Study, *Journal of Irrigation and Drainage Engineering,* Vol. 147, paper 04021001, 2021.

30. M. Asl, R. Daneshfaraz, J.P. Abraham, S. Valizadeh, Effects of hydraulic characteristics, sedimentary parameters, and mining of bed material on scour depth of bridge pier groups, *Joural of Performance of Constructed Facilities*, Vol. 35, paper no. 04020148, 2021.

31. G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change,* Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 700, top 1%, July 2021.**

32. F. Salamsi and J.P. Abraham, An expert System for Determining Discharge Coefficients for Inclined Slide Gates Using Genetic Programing, *Journal of Irrigation and Drainage Engineering*, Vol. 146, paper number 060200013, 2020.

33. N. Sartipi, F. Salamsi, J. Abraham, and A.D. Dalir, Investigation of the Effect of Depth and Distance Between Cutoff Walls on Uplift Force for Gravity Dams, *International Journal of Environmental Science and Technology*, Vol. 18. pp. 1361-1378, 2021.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

34. R. Daneshfaraz, R. Norouzi, M. Macedi, A. Bazyar, and J.P. Abraham, Laboratory Study of Energy dissipation in Inclined Drops with a Screen, *Journal of Applied Water Engineering and Research*, Vol. 9, pp. 184-193, 2021.

35. A. Ghaderi, M. Shokri. J.P. Abraham, Estimation of Actual Evapotranspiration Using Remote Sensing Method and SEBAL Algorithm- A Case Study: Ein Khosh Plain, Iran, *Hydrology*, (in press).

36. A. Ghaderi, M. Dasineh, R. Danesfarak, and J.P. Abraham, Reply to the Discussion on Paper: 3-D Numerical Simulation of Water Flow over a Broad Created weir with Openings by Daneshfaraz et al 2019, *ISH Journal of Hydraulic Engineering*, (in press).

37. A. Ghaderi, R. Daneshfaraz, J.P. Abraham, and M. Torabi, Effect of Different Channels on Discharge Coefficient of Labyrinth Weirs, *Teknik Dergi*, Vol. 32, (pages in press), 2021.

2020

38. F. Salamsi, M. Nouri, and J.P. Abraham, Upstream Cutoff and Downstream Filters to Control Seepage in Dams, *Water Resources Management*, Vol. 34, pp. 4271-4288, 2020.

39. L. Cheng, K.E. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, J.T Fasullo, G. Li, X. Zhao, and J. Zhu, Improved estimates of changes in upper ocean salinity and the hydrological cycle, *Journal of Climate*,Vol.33, pp. 10357-10381, 2020.

40. F. Salamsi, R. Norouzi, J.P. Abraham, B. Nourani, S. Samadi, Effect of Inclined Clay Core on Embankment Dam Seepage and Stability Through LEM and FEM, *Geotechnical and Geological Engineering*, Vol. 38, pp. 6571-6586, 2020.

41. A. Ghaderi, R. Daneshfaraz, S. Abbasi, and J.P. Abraham, Numerical Analysis of the Hydraulic Characteristics of Modified Labyrinth Weirs, *International Journal of Energy and Water Resources,* Vol. 4, pp. 425-436, 2020.

42. J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 376, top 1%, July, 2021.**

43. A. Ghaderi, R. Daneshfaraz, M. Torabi, J.P. Abraham, and H.M. Azamathulla, Experimental Investigation on Effectiving Scouring Parameters Downstream from Stepped Spillways, *Water Supply*, Vol. 20, pp. 1988-1998, 2020.

44. F. Salamsi, and J.P. Abraham, Predicting Seepage from Unlined Earthen Channels Using the Finite Element Method and Multi Variable Nonlinear Regression, *Agriculatural Water Management*, Volume 234, Paper no. 106148, 2020.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

45. F. Salamsi, B. Naourani, and J.P. Abraham, Investigation of the Effect of Different Configurations of Double-Cutoff Walls Beneath Hydraulic Structures on Uplift Forces and Exit Hydraulic Gradients, *Journal of Hydrology*, vol. 586, dpo: 10.1016/j.hydrol.2020.123858, 2020.

46. A. Ghaderi, S. Abbasi, J.P. Abraham, H. M. Azamathulla, Efficiency of Trapezoidal Labyrinth Shaped Stepped Spillways, *Flow Measurement and Instrumentation*, paper no. 101711, 2020, doi: 10.1016/j.flowmeasinst.2020.101711.

47. L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **(This paper was in the top 100 of all published scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021).**

48. F. Salamsi, and J.P. Abraham, Discussion of "Hydrodynamics of Rectangular Broad-Crested Porous Weirs" by Akbar Safarzadeh and Seyed Hossein Mohajeri, *J. Irrig. Drain. Eng*. Vol. 146, paper no. 07020004, 2020.

49. R. Daneshfaraz, M.M. Asl, S. Razmi, R. Norouzi, and J.P. Abraham, Experimental Investigation of the Effect of Dual Horizontal Screens on the Hydraulic Performance of a Vertical Drop, *International Journal of Environmental Science and Technology*, Vol. 17, pp. 2927-2937, 2020.

50. J.M. Gorman, et al., Memoriam, Ephraim Sparrow, *International Journal of Heat and Mass Transfer*, Vol. 148, article no. 18755, 2020.

51. F. Salmasi, J.P. Abraham, Discharge coefficients for ogee weirs including the effects of a sloping upstream face, *Water Science and Engineering*, doi: 10.2166/ws.2020.064, 2020.

52. F. Salamsi, and Abraham J.P., Discussion of "Hydrodynamics of Retangular Broad-Crested Porous Weirs" by Akbar Safrazadeh and Seyed Moharjeri, *Journal of Irrigation and Drainage Engineering*, Vol. 146, doi: 10.1061/%28ASCE%29IR.1943-4774.0001450, 2020.

53. R. Daneshfaraz, E. Aminvash, R. Esmaeli, S. Sadeghfam, and J.P. Abraham Experimental and Numerical Investigation for Energy Dissipation of Supercritical Flow in Sudden Contractions*, Journal of Groundwater Science and Engineering*, Vol. 8, pp. 396-404, 2020.

54. R. Daneshfaraz, O. Minaeri, J.P. Abraham, and S. Dadashi, 3-D Numerical Simulation of Flow Over a Broad-Crested Weir with Opening, *Journal of Hydraulic Engineering*, Vol. 24, doi: 10.1080/09715010.1581098, 2020.

2019

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

55. A. Ghaderi, M. Dasineh, S. Abbasi, and J.P. Abraham, Investigation of Trapezoidal Sharp-Crested Weir Discharge Coefficients Under Subcritical Flow Regimes, *Applied Water Science*, Vol. 10, article no. 31, 2019.

56. G. Li, Y. Zhang, J. Xiao, J.P. Abraham, L. Cheng, and J. Zhu, Examining the Salinity change in the upper Pacific Ocean During the Argo Period, *Climate Dynamics* Vol. 53, pp. 6055-6074, 2019.

57. J.P. Abraham, K. Diller, A Review of Hot Beverages – Satisfying Consumer Preferences and Safety, *J. Food Science*, Vol. 84, pp. 2011-2014, 2019.

58. J.M. Gorman, et al., In Memoriam, Ephraim M. Sparrow (May 27, 1928 – August 1, 2019), *Numerical Heat Transfer Part A*, Vol. 76, pp. 181-184, 2019.

59. F. Jafari, F. Salamsi, and J.P. Abraham, Numerical Investigation of Granular Filer Under the Bed of a Canal, *Applied Water Science*, Vol. 9, Article no. 137, 2019

60. J. P. Abraham, Heat risks associated with synthetic fields, *International Journal of Hyperthermia*, Vol. 24, pp. 516-517, 2019.

61. T. Wei and J.P. Abraham, Heat transfer regimes in fully developed circular tube flows, a map of flow regimes, *International Communications in Heat and Mass Transfer*, Vol. 104, 147-152, 2019.

62. B.D. Plourde, A. Gikling, T. Marsh, M.A. Riemenschneider, J.L. Fitzgerald, W.J. Minkowycz, J. Kiplagat, J.P. Abraham, Design and Evaluation of a Concentrated Solar-Powered Thermal-Pasteurization System, *Journal of Solar Energy Research*, Vol. 6, pp. 34-42, 2019.

63. E. Dodangeh, K. Shahedi, K. Solalani, J.T., Shiu, J.P. Abraham, Data-based bivariate uncertainty assessment of extreme rainfall-runoff using copulas: Comparison between annual maximum series (AMS) and peaks over threshold (POT), *Environmental Monitoring and Assessment*, Vol. 191:67, 2019.

64. F. Salamsi, M. Nouri, and J.P. Abraham, Laboratory Study of the Effect of Sills on Radial Gate Discharge Coefficient, *KSCE Journal of Civil Engineering*, Vol. 23, pp. 2117-2125, 2019.

65. Benoit et al., Measuring Global Ocean Heat Content to Estimate the Earth Energy Imbalance, *Frontiers in Marine Science*, *OceanObs'19: An Ocean of Opportunity*, Vol. 6, pp. 198-228, doi: 10.3389/fmars.2019.00432, 2019.

66. L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues record global warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

67. L.Cheng, G. Wang, J.P. Abraham, G. Huang, Decadal ocean heat redistribution since the late 1990s and its association with key climate modes, *Climate*, Vol. 6, 91, 2019.

68. G. Wang, L Cheng, C. Li, A. Storto, H. Liu, J. Chen, and J.P. Abraham, Synthetic Profile Dataset for Evaluating Uncertainty of Ocean Heat Content Estimate, *J. Institute for Atmospheric Physics*, (submitted).

69. L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021, ranked 18 out of the top 30 papers in the field of Global Sustainabilty.**

70. J.P. Abraham, E.M. Sparrow, J.M. Gorman, Y. Zhao, and W.J. Minkowycz, Application of an Intermittency Model for Laminar, Transitional, and Turbulent Internal Flows, *Journal of Fluids Engineering*, Vol. 141, paper no. 071204, 2019.

71. J.P. Abraham, J. R. Stark, J.M. Gorman, E. M. Sparrow, W.J. Minkowycz, Tissue Burns Due to Contact Between a Skin Surface and Highly Conducting Metallic Media in the Presence of Inter-Tissue Boiling, *Burns*, Vol. 45, pp. 369-378, 2019.

72. J.M. Gorman, E. M. Sparrow, C.J. Smith, A. Ghoash, J.P. Abraham, R. Daneshfaraz, A. Rezazedeh Joudi, In-bend pressure drop and post-bend heat transfer for a bend with a partial blockage at its inlet, *Numerical Heat Transfer A*, Vol. 73, pp. 743-767, 2018.

73. A. Bahro, Z. Igyarto, C. Williams, J.P. Abraham, and B.J. Martinsen, Treatment of Critical Hand Schemia via Orbital Atherectomy and Focal Force Balloon Angioplasty: A Mini-Review, *Cardiovascular Revascularization Medicine*, Vol. 20, pp. 248-253, 2019.

2018

74. J.P. Abraham, R. Maki, Hydrodynamics of Laminar Flow Through Dimpled Pipes, *MOJ Civil Engineering*, Vol. 4, pp. 150-154, 2018.

75. L. Cheng, H. Luo, T. Boyer, R. Cowley, J. Abraham, V. Gouretski, F. Reseghetti, and J. Zhu, How Well Can We Correct Systematic Errors in Historical XBT Data? *Journal of Atmospheric and Oceanic Technology*, Vol. 35, pp. 1103-1125, 2018.

76. G. Wang, L. Cheng, J.P. Abraham, C. Li, Consensuses and Discrepancies of basin-scale ocean heat content changes in different ocean analyses, *Climate Dynamics*, Vol. 50, pp. 2471-2487, 2018

77. M. T. Sattari, H. Feyzi, and J.P. Abraham, Comparing the Performance of Genetic and Differential Evolution Algorithms in Optimum Operation of Reservoir While Considering the Minimum Environmental Demand, *Stochastic Environmental Research and Risk Assessment (SERR)*, (submitted).

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

78. R. Daneshfaraz, A.R. Joudi, J.P. Abraham, Numerical Investigation on the Effect of Sudden Contraction on Flow Behavior in a 90-Degree Bend, *Korean Journal of Civil Engineering*, Vol. 22, pp 603-612, 2018.

79. M. T. Sattari, A. Farkhondeh, and J.P. Abraham, Estimation of Sodium Adsorption Ratio Indicator Using Data Mining Methods: A Case Study in Urmia Lake Basin, Iran, *Environmental Science and Pollution Research*, Vol. 25, pp. 4776-4786, 2018.

80. M.T. Sattari, R. Misabbasi, R. S. Sushab, and J.P. Abraham, Prediction of Groundwater Level in the Ardebil Plain Using Support Vector Regression and the M5 Tree Model, *Groundwater Journal,* Vol. 56, pp. 636-646, 2018.

81. L. Cheng, K.E. Trenberth, J. T. Fasullo, J.P. Abraham, T.L. Boyer, K. von Schuckmann, and J. Zhu, Taking the Pulse of the Planet, *EOS,* Vol. 98, pp 14-15, 2018.

82. J.P. Abraham, B.D Plourde, L. J. Vallez, Comprehensive review and study of buoyant air flow within positive-pressure hospital operating rooms, *Numerical Heat Transfer A*, Vol. 72, pp. 1-20, 2018.

83. M.R. Sattari, M. Pal, R. Mirabbasi, and J.P. Abraham, Ensemble of M5 Model Tree Based Modelling of Sodium Adsorption Ratio, *Journal of Artificial Intelligence and Data Mining*, Vol. 6, pp. 69-78, 2018.

2017

84. J.P. Abraham, A Global Warming Primer: Answering Your Questions about the Science, the Consequences, and the Solutions, Physics Today, Vol. 70, no. 3, 2017.

85. M.R. Sattari, Dodangeh, and J.P. Abraham, Estimation of Daily Soil Temperature Via Data Mining Techniques in Semi-Arid Climate Conditions, *Earth Sciences Research Journal*, Vol. 21, pp. 85-93, 2017.

86. J.P. Abraham, L. Cheng, M.E. Mann, Future Climate Projections Allow Engineering Planning, *Forensic Engineering*, Vol. 170, pp. 54-57, 2017.

87. B.D. Plourde, L.J. Vallez, B. B. Nelson-Cheeseman, J.P. Abraham, Transcutaneous Recharge: A Comparison of Numerical Simulation to In Vivo Experiments *Neuromodulation*, Vol. 20, pp. 613-621, 2017.

88. E.M. Sparrow, B.B Nelson-Cheeseman, W.J. Minkowycz, J.M. Gorman, and J.P. Abraham, Use of Multi-Lumen Catheters to Preserve Injected Stem Cell Viability and Injection Dispersion*, Cardiovascular Revascularization Medicine*, Vol. 18, pp. S49-S57, 2017.

89. L.J. Vallez, B.D. Plourde, J.E. Wentz, B. B. Nelson-Cheeseman, J.P. Abraham, A Review of Scald Burn Injuries, *Internal Medicine Review*, Vol. 3, pp. 1-18, 2017.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

90. R. Daneshfaraz, H. Sadeghi, A. R. Joudi, J.P. Abraham, Experimental Investigation of Hydraulic Jump Characteristics in Contractions and Expansions, *Sigma Journal of Engineering and Natural Sciences*, Vol. 35, pp. 87-98, 2017.

91. R. Daneshfaraz, A. R. Joudi, A. Ghaderi, J.P. Abraham, Comparisons of CFD Simulations with Physical Models of Dam Spillway Flow (Case Study: Azad Dam Spillway, Iran), *Journal of Dams and Reservoirs*, (accepted).

92. L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

93. J.M. Gorman, E., M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Transfer Design Methodology Treating a Heat Exchanger Device and its Fluid-Mover Partner as a Single System, *Heat Transfer Engineering*, Vol. 38, pp. 841-852, 2017.

94. R.T. Bourdon, B.B. Nelson-Cheeseman, and J.P. Abraham, Review on the Treatment and Avoidance of Scald Injuries, *World Journal of Dermatology*, Vol. 6, pp. 17-26, 2017.

2016

95. B.D. Plourde, J.R. Stark, J. P. Abraham, A New Catheter Technology to Deliver Vascular Stem-Cells, *Global Journal of Stem Cell Biology and Transplantation*, Vol. 2, pp. 7-16, 2016.

96. J.R. Stark, S.R. Romero, J.M. Gorman, J.P. Abraham, E.M. Sparrow, Modulated-Power Implantable Neuromodulation Devices and Their Impact on Surrounding Tissue Temperatures, *Journal of Biomedical Science and Engineering*, Vol. 9, pp. 545-562, 2016.

97. L. Cheng, K.E. Trenberth, M.D. Palmer, J. Zhu, and J.P. Abraham Observed and Simulated Full-Depth Ocean Heat Content Changes for 1970-2005, *Ocean Sciences*, Vol. 12, pp. 925-935, 2016.

98. J.M. Gorman, E.M. Sparrow, J.P. Abraham, W. J. Minkowycz, Evaluation of the Efficacy of Turbulence Models for Swirling Flows and Effect of Turbulence Intensity on Heat Transfer, *Numerical Heat Transfer B*, Vol. 70, pp. 485-502, 2016.

99. J.P. Abraham, B.B. Nelson Cheeseman, E. M. Sparrow, J.E. Wentz, J.M. Gorman, S. E. Wolf, Comprehensive Method to Predict and Quantify Scald Burns from Beverage Spills, *Int. J. Hyperthermia*, Vol. 32, pp. 900-910, 2016.

100. B.D. Plourde, L.J. Vallez, B. Sun, B.B. Nelson-Cheeseman, J.P. Abraham, Alterations of Blood Flow Through Arteries Following Atherectomy and the Impact on Pressure Variation and Velocity, *Cardiovascular Engineering and Technology*, Vol. 7, pp. 280-289, 2016.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

101. N.K. Langat, T. Thorusa, J.P. Abraham, J. Wanyoko, Performance of an Improved Fluidized System for Processing Green Tea, *World Academy of Science Engineering and Technology*, Vol. 10, 1045-1050, 2016.

102. L. Cheng, J. Abraham, G. Goni, T. Boyer, S. Wijffels, R. Cowley, V. Gouretski, F. Reseghetti, S. Kizu, S. Dong, F. Bringas, M. Goes, L. Houpert, J. Sprintall, and J. Zhu, XBT Science: Assessment of XBT Biases and Errors, *Bulletin of the American Meteorological Society*, June, pp. 924-933, 2016.

103. J.P. Abraham, R. Cowley, L. Cheng, Quantification of the Effect of Water Temperature on the Fall Rate of eXpendable BathyThermographs, *Journal of Atmospheric and Oceanic Technology*, Vol. 6, pp. 1271-1284, 2016.

104. R.T. Bourdon, B.B. Nelson-Cheeseman, and J.P. Abraham, Prediction, Identification, and Initial Treatment Guidelines for Scald Injuries, *Austin Journal of Emergency and Critical Care Medicine, Special Issue on Burns*, Vol. 3, pp. 1043-1049, 2016.

105. J.C.K. Tong, J.P. Abraham, J.M.Y. Tse, W.J. Minkowycz, and E.M. Sparrow, New Archive of Heat Transfer Coefficients from Square and Chamfered Cylinders in Crossflow, *International Journal of Thermal Sciences*, Vol. 105, pp. 218-223, 2016.

106. L. Cheng, K.E. Trenberth, M.D. Palmer, J. Zhu, and J.P. Abraham, Observed and Modeled Ocean Heat Content Changes Since 1970, *Ocean Sciences,* Vol 12, pp. 925-936, 2016.

107. R. Daneshfaraz, A. Ghahramanzadeh, A. Ghaderi, A. Rezazadeh Joudi, and J.P. Abraham, Investigation of the Effect of Edge Shape on Characteristics of Flow Under Vertical Gates, *Journal AWWA*, Vol. 8, pp. E425-432, 2016.

108. J.P. Abraham, B.D. Plourde, L.J. Vallez, and B.B. Nelson-Cheeseman, Correcting a Prevalent Misunderstanding of Burns, *Burns*, Vol. 42, pp. 715-716, 2016.

109. J. P. Abraham and B.D. Plourde, Validation of Numerically Simulated Tissue Temperatures During Transcutaneous Recharge of Neurostimulation Systems, *Journal of Neuromodulation*, Vol. 19, pp. 161-170. 2016.

110. L.J. Vallez, B.D. Plourde, and J.P. Abraham, A New Computational Thermal Model for the Whole Human Body: Applications to Patient Warming Blankets, *Numerical Heat Transfer A*, Vol. 69, pp. 227-241, 2016.

2015

111. J.P. Abraham, B.D. Plourde, B. Sun, L.J. Vallez, and C.S. Staniloae, The Effect of Plaque Removal on Pressure Drop and Flowrate Through a Stenotic Lesion*, Biology and Medicine,* Vol. 8, article no. 1000261, 2015.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

112. L.J. Vallez, B. Sun, B.D. Plourde, J.P. Abraham, and C.S. Staniloae, Numerical Analysis of Arterial Plaque Thickness and its Impact on Artery Wall Compliance, *J. Cardiovascular Medicine and Cardiology*, Vol. 2, pp. 26-34, 2015.

113. D. Nguyen, J. M. Gorman, E.M. Sparrow, and J.P. Abraham, Convective Heat Transfer Enhancement Versus Disenhancement: Impact of Fluid-Mover Characteristics, *Applied Thermal Engineering,* Vol. 90, pp. 242-249, 2015.

114. B. Sun, L.J. Vallez, D.B. Plourde, J. R. Stark, and J.P. Abraham, Influence of Supporting Tissue on the Deformation and Compliance of Healthy and Diseased Arteries, *Journal of Biomedical Science and Engineering*, Vol. 8, pp. 490-499, 2015.

115. J.P. Abraham, B.D Plourde, L.J. Vallez, J.R. Stark, and K. R. Diller, Estimating the Time and Temperature Relationship for Causation of Deep-partial Thickness Skin Burns, *Burns*, Vol. 41, pp. 1741-1747, 2015.

116. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, US Climate Variability and Predictability Program (CLIVAR) Summer 2015, Vol. 13, pp. 6-9, 2015.

117. L. Cheng, J. Zhu, and J.P. Abraham, Global Upper Ocean Heat Content Estimation: Recent Progresses and the Remaining Challenges, *Atmospheric and Oceanic Science Letters*, Vol. 8, pp. 333-338, 2015.

118. M. Richardson, Z. Hausfather, D.A. Nuccitelli, K. Rice, and J.P. Abraham, Misdiagnosis of Earth Climate Sensitivity Based on Energy Balance Model Results, *Science Bulletin*, Vol. 60, pp. 1360-1377, 2015.

119. B.D. Plourde and J.P. Abraham, Design and Development of a New Cell Infusion Catheter, *World Biomedical Frontiers*, ISSN:2328-0166, 2015.

120. B.D. Plourde, J.P. Abraham, and W.J. Minkowycz, Continuous Flow Solar Thermal Pasteurization of Drinking Water: Methods, Devices, Microbiology, and Analysis, *Renewable Energy,* Vol. 81, pp. 795-803, 2015.

121. J.M. Gorman, M. Carideo, E.M. Sparrow, and J.P. Abraham, Heat Transfer and Pressure Drop Comparison of Louver- and Plain-finned Heat Exchangers Where One Fluid Passes Through Flattened Tubes, *Case Studies in Thermal Engineering,* Vol. 5, pp. 122-126, 2015.

122. J.C.K. Tong, J.P. Abraham, J.M.Y. Tse, and E.M. Sparrow, Impact of Chamfer Contours to Reduce Column Drag, *Engineering and Computational Mechanics*, Vol. 168, pp. 79-88, 2015.

123. D. Egbe, T. Mayah, E. Ebota, P. Egbe, J. Abraham, Performance Evaluation and Improvement on a Melon Seed Shelling Machine, *World Journal of Agricultural Sciences and Engineering*, Vol. 1, pp. 157-10, 2015.

4232 29th Ave.
Minneapolis, MN 55406
John P. Abraham
jpabraham@stthomas.edu
612-963-2169

124. A. Lundardelli, J.E. Wentz, J.P. Abraham, and B.D. Plourde, Shielding Nozzle Design and Analysis for Atomization-Based Cutting Fluid Systems in Micromachining, *ASME Journal of Micro- and Nano-Manufacturing*, Vol. 3, paper no. 024501, 2015.

125. N. Langat, T. Thoruwa, J. Wanyoko, J. Kiplagat, B.D Plourde, and J.P. Abraham, Models and Experiments for Energy Consumption and Quality of Green Tea Drying, *Energy Science and Engineering*, Vol. 3, 43-50, 2015.

126. T. Scambos and J.P. Abraham, Antarctic Ice Sheet Mass Loss and Future Sea Level Rise, *Forensic Engineering, Proceedings of the Institute of Civil Engineers*, Vol. 168, pp. 81-84, 2015.

127. J.P. Abraham, J.R. Stark, W.J. Minkowycz, Extreme weather: Observations of Precipitation Changes in the USA, *Forensic Engineering, Proceedings of the Institution of Civil Engineers*, Vol. 168, pp. 68-70, 2015.

2014

128. N. Dib, D.B. Schwalbach, B.D. Plourde, R.E. Kohler, D. Dana, and J.P. Abraham, Impact of Balloon Inflation Pressure on Cell Viability with Single and Multi Lumen Catheters, *Cardiovascular Translation Research*, Vol. 7, pp. 781-787, 2014.

129. J.P. Abraham, J.T. Fasullo, and G. Laden, Continued Global Warming in the Midst of Natural Climate Fluctuations, *Reports of the National Center for Science Communication*, 34(6), 2014.

130. N. Dib, J.P. Abraham, B.D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, S.R. D'Silva, T.R. Flower, and R.E. Kohler, TCT-155 A Novel Multi Lumen Compliant Balloon Catheter (ND Infusion Catheter) Preserves Stem Cell Viability and Improves Dispersion When Compared to a Standard Single Lumen Balloon Angioplasty Catheter, *Journal American College of Cardiology*, Vol. 64, 11, 2014.

131. J.P. Abraham, B.D. Plourde, and J.R. Stark, Cryosurgical Treatment of Cancer: The Importance of Modeling, *Journal of Cancer Science and Therapy,* Vol. 6, 2014 (abstract).

132. J.P. Abraham, S. Kumar, B.R. Bickmore, and J.T. Fasullo, Issues Related to the Use of One-Dimensional Ocean Diffusion Models for Determining Climate Sensitivity, *Journal of Earth Science and Climate Change*, Vol. 5, paper 1000220, 2014.

133. T. Shepard, J.P. Abraham, D.S. Schwalbach, S. Kane, D. Sigling, and T. Harrington, Velocity and Density Effect on Impact Force During Water Entry of Spheres, *Journal of Geophysics and Remote Sensing*, Vol. 3, paper no. 1000129, 2014.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

134. D.S. Schwalbach, T. Shepard, S. Kane, D. Siglin, T. Harrington, and J.P. Abraham, Effect of Impact Velocity and Mass Ratio During Vertical Sphere Water Entry, *Developments and Applications of Oceanic Engineering*, Vol. 3, 55-62, 2014.

135. J.P. Abraham, B.D. Plourde, J.R. Stark, and W.J. Minkowycz, Improvements to the Quality and Quantity of Ocean Heat Content Measurements, *Journal of Earth Science and Climate Change,* Vol. 5, pp. 100, 2014 (abstract).

136. J.P. Abraham, B.D. Plourde, and K.E. Trenberth, Closing Earth's Energy Balance, *Journal of Earth Science and Climate Change*, Vol. 5, pp. 69, 2014 (abstract).

137. J.M. Gorman, E.M. Sparrow, and J.P. Abraham, Temperature Determination by Means of Optoacoustic Measurements, *Studies in Engineering and Technology*, Vol. 1, 15-20, 2014.

138. J.M. Gorman, E.M. Sparrow, and J.P. Abraham, Slot Jet Impingement Heat Transfer in the Presence of Jet Axis Switching, *International Journal of Heat and Mass Transfer,* Vol. 78, 50-57, 2014.

139. J.P. Abraham, A review of the HANDY Study, *Cosmopolis*, Vol. 2014-1, pp. 8-87, 2014.

140. J.P. Abraham, Climate Change in the Midwest: Impacts, Risks, Vulnerabilities, and Adaptation. A Review of New Biological Books, *The Quarterly Review of Biology*, Vol. 89, pp. 171-172, 2014.

141. B.D. Plourde, D.B. Schwalbach, J.P. Abraham, and R.E. Kohler, Intracoronary Injection of Medication from Multi-lumen Injection Catheters, *Journal of Medical Devices,* Vol. 8, paper number 020901, 2014.

142. J.P. Abraham, J. Cook, J. T. Fasullo, P. H. Jacobs, S. A. Mandia, and D. A Nuccitelli, Review of the Consensus and Asymmetric Quality of Research on Human-Induced Climate Change, *Cosmopolis*, Vol. 2014-1, pp. 3-18, 2014.

143. B.L. Viglianti, M.W. Dewhirst, J.M. Gorman, and J.P. Abraham, E.M. Sparrow, Rationalization of Thermal Injury Quantification Methods: Application to Skin Burns, *Burns*, Vol. 40, pp. 896-902, 2014.

144. N.M. Naughton, B.D. Plourde, J.R. Stark, S. Hodis, and J. P. Abraham, Impacts of Waveforms on the Fluid Flow, Wall Shear Stress, and Flow Distribution in Cerebral Aneurysms and the Development of a Universal Reduced Pressure, *J. Biomedical Science and Engineering*, Vol. 7, 7-14, 2014.

145. J.M. Gorman, J.P. Abraham, D. B. Schwalbach, T. S. Shepard, J.R. Stark, and F. Reseghetti, Experimental Verification of Drag Forces on Spherical Objects Entering Water, *Journal of Marine Biology and Oceanography*, Vol. 3, paper no. 1000126, 2014.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

146. S. Beacher, E.M. Sparrow, J.M. Gorman, and J.P. Abraham, Theory and Numerical Simulation in Thermochemical Ablation, *Numerical Heat Transfer Part A*, Vol. 66, pp. 131-143, 2014.

147. J.P. Abraham, J.M. Gorman, F. Reseghetti, E.M. Sparrow, J.R. Stark, and T.G. Shepard, Modeling and Numerical Simulation of the Forces Action on a Sphere During Early-Water Entry, *Ocean Engineering,* Vol. 76, 1-9, 2014.

148. J.M. Gorman, J.P. Abraham, and E.M. Sparrow, A Novel, Comprehensive Numerical Simulation for Predicting Temperatures Within Boreholes and the Adjoining Rock Bed, *Geothermics*, Vol. 50, pp. 213-219, 2014.

2013

149. J.P. Abraham, B.D. Plourde, G.S. Mowry, and E.M. Sparrow, Experimental Test of Multi-Stage Vertical Axis Turbines for Cellular Communication Applications, *ASME Proceedings,* Paper Number ES2012-91025, pp. 1333-1339, 2013.

150. D.B. Schwalbach, B.D. Plourde, J.P. Abraham, and R.E. Kohler, Drug Dispersion for Single- and Multi-Lumen Catheters, *Journal of Biomedical Science and Engineering*, Vol. 6, pp. 1021-1028, 2013.

151. N. Dib, R.E. Kohler, J.P. Abraham, B.D. Plourde, D.B. Schwalbach, D. Dana, B.J. Baird, T.R. Flower, L. Myers, and K. Hunkler, TCT-811 Stem Cell Viabilitiy Significantly Reduced After Passing Through a Standard Single Lumen Over-the-Wire 0.014 Balloon Angioplasty Cather, *Journal of the American College of Cardiology*, Vol. 62, B246, 2013.

152. D.A. Nuccitelli, J.P. Abraham, R.E. Benestad, and S.A. Mandia, Comment on: Akasofu, S.-I. On The Present Halting of Global Warming, *Climate*, Vol. 1, pp. 76-83, 2013.

153. J.M. Gorman, E. M. Sparrow, and J.P. Abraham, Differences Between Measured Pipe Wall Surface Temperatures and Internal Fluid Temperatures, *Case Studies in Thermal Engineering,* Vol. 1, 13-16, 2013.

154. J.R. Stark, J.M. Gorman, E.M. Sparrow, J.P. Abraham, and R.E. Kohler, Controlling the Rate of Penetration of a Therapeutic Drug Into the Wall of an Artery by Means of a Pressurized Balloon, *Journal of Biomedical Science and Engineering*, Vol. 6, pp. 527-532, 2013.

155. J.P. Abraham, M. Baringer, N.L. Bindoff, T. Boyer, L.J. Cheng, J.A. Church, J.L. Conroy, C.M. Domingues, J.T. Fasullo, J. Gilson, G. Goni, S.A. Good, J. M. Gorman, V. Gouretski, M. Ishii, G.C. Johnson, S. Kizu, J.M. Lyman, A. M. Macdonald, W.J. Minkowycz, S.E. Moffitt, M.D. Palmer, A.R. Piola, F. Reseghetti, K. Schuckmann,K.E. Trenberth, I. Velicogna, and J.K. Willis, A Review of Global Ocean Temperature Observations: Implications for Ocean Heat Content Estimates

4232 29th Ave.
Minneapolis, MN 55406
John P. Abraham
jpabraham@stthomas.edu
612-963-2169

and Climate Change, *Reviews of Geophysics*, Vol. 51, pp 450-483, 2013. **Altmetric score = 173, top 5%, January 2021.**

156. J.P. Abraham, J.R. Stark, J.M. Gorman, E.M. Sparrow, and R.E. Kohler, A Model of Drug Deposition Within Artery Walls, *J. Medical Devices*, Vol. 7, paper no. 020902, 2013.

157. E.M. Sparrow, N.T. Littlejohn, J.M. Gorman, and J.P. Abraham, Mass Transfer and Particle Separation by Swirl-Chamber and Swirl-Tube Devices, *Numerical Heat Transfer A,* Vol. 64, 611-620, 2013.

158. E.M. Sparrow, J. M. Gorman, and J.P. Abraham, Quantitative Assessment of the Overall Heat Transfer Coefficient U, *Journal of Heat Transfer*, Vol. 135, paper no. 061102, 2013.

159. J.P. Abraham, E.M. Sparrow, J.M. Gorman, J.R. Stark, and R. E. Kohler, A Mass Transfer Model of Temporal Drug Deposition in Artery Walls, *International Journal of Heat and Mass Transfer*, Vol. 58, pp. 632-638, 2013.

160. R.R. Rend, E. M. Sparrow, D. W. Bettenhausen, and J. P. Abraham, Parasitic Pressure Losses in Diffusers and in Their Downstream Piping Systems for Fluid Flow and Heat Transfer, *International Journal of Heat and Mass Transfer*, Vol. 61, pp. 56-61, 2013.

2012

161. E.M. Sparrow, J.M. Gorman, K.S. Friend, and J.P. Abraham, Flow Regime Determination for Finned Heat Exchanger Surfaces with Dimples/Protrusions, *Numerical Heat Transfer*, Vol. 63, pp. 245-256, 2012.

162. B.D. Plourde, J.P. Abraham, G.S. Mowry, and W.J. Minkowycz, Simulations of Three-Dimensional Vertical-Axis Turbines for Communications Applications, *Wind Engineering*, Vol. 36, pp. 443-454, 2012.

163. J.P. Abraham, B.D. Plourde, G.S. Mowry, and W.J. Minkowycz, Summary of Savonius Wind Turbine Development and Future Applications for Small-Scale Power Generation, *Journal of Renewable and Sustainable Energy*, Vol. 4, paper no. 042703, 2012.

164. J.M. Gorman, EM. Sparrow, J.P. Abraham, and G.S. Mowry, Operating Characteristics and Fabrication of a Uniquely Compact Helical Heat Exchanger, *Applied Thermal Engineering*, Vol. 5, pp. 1070-1075, 2012.

165. E.M. Sparrow, J.M. Gorman, A. Trawick, and J.P. Abraham, Novel Techniques for Measurements of Thermal Conductivity of Both Highly and Lowly Conducting Media, *International Journal of Heat and Mass Transfer*, Vol. 55, pp. 4037-4042, 2012.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

166. J.P. Abraham, J.M. Gorman, F. Reseghetti, E.M. Sparrow, and W.J. Minkowycz, Drag Coefficients for Rotating Expendable Bathythermographs and the Impact of Launch Parameters on Depth Predictions, *Numerical Heat Transfer A*, Vol. 62, pp. 25-43, 2012.

167. M. Nelson and J.P. Abraham, Hemodynamics of AV Grafts for Hemodialysis Access, *Journal of Medical Devices,* Vol. 6, article no. 017553, 2012.

168. J.P. Abraham and J. Jeske, Cryosurgical Simulations for Ablation of Kidney Tumors, *Journal of Medical Devices,* Vol. 6, article no 017504, 2012.

169. J.P. Abraham, J.M. Gorman, F. Reseghetti, W.J. Minkowycz, and E. M. Sparrow, Turbulent and Transitional Modeling of Drag on Oceanographic Measurement Devices, *Computational Fluid Dynamics and its Applications* 2012, article ID 567864, doi:10.1155/2012/567864.

2011

170. J.P. Abraham, J.M. Gorman, F. Reseghetti, K.E. Trenberth, and W.J. Minkowycz, A New Method of Calculating Ocean Temperatures Using Expendable Bathythermographs*, Energy and Environment Research*, Vol. 1, pp. 2-11, 2011.

171. J.R. Stark, J.M. Gorman, M.P. Hennessey, F. Reseghetti, J. Willis, J. Lyman, J.P. Abraham, and M. Borghini, A Computational Method for Determining XBT Depths, *Ocean Sciences*, Vol. 7, pp. 733-743, 2011.

172. B.D. Plourde, J. P. Abraham, G.S. Mowry, and W.J. Minkowycz, Use of Small-Scale Wind Energy to Power Cellular Communication Equipment, *Sensors and Transducers*, Vol. 13, pp. 53-61, 2011.

173. J.P. Gorman, E.M. Sparrow, G.S. Mowry, and J.P. Abraham, Simulation of Helically Wrapped, Compact Heat Exchangers, *Journal of Renewable and Sustainable Energy*, Vol. 3, article no. 043120, 2011.

174. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Surrogate Human Tissue Temperatures Resulting from Misalignment of Antenna and Implant During Recharging of a Neuromodulation Device, *Journal of Neuromodulation*, Vol. 14, pp. 501-511, 2011.

175. K.E. Trenberth, J.T Fasullo, and J.P. Abraham, Issues in Establishing Climate Senstivity in Recent Studies, *Remote Sensing,* Vol. 3, pp. 2051-2055, 2011.

176. R.D. Lovik, E. M. Sparrow, J. P. Abraham, C. Zelmer, S. Oh, K. Friend, and D. K. Smith, Effect of Component Misalignment on Human Tissue Temperatures Associated with Recharged Nueromodulation Devices, *Journal of Medical Devices*, Vol. 5, 0207516, 2011.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

177. T. Gebreegziabher, E.M. Sparrow, J.P. Abraham, E. Ayorinde, and T. Singh, High-Frequency Pulsatile Pipe Flows Encompassing All Flow Regimes, *Numerical Heat Transfer A*, Vol. 60, pp. 811-826, 2011.

178. J.P. Abraham, M.P. Hennessey, and W.J. Minkowycz A Simple Algebraic Model to Predict Burn Depth and Injury, *International Communications in Heat and Mass Transfer*, Vol. 38, pp. 1169-1171, 2011.

179. J.P. Abraham, B.D. Plourde, G.S. Mowry, E. M. Sparrow, and W.J. Minkowycz, Numerical Simulation of Fluid Flow Around a Vertical-Axis Turbine, *Journal of Renewable and Sustainable Energy*, Vol. 3, article no. 033109, 2011 (doi:10.1063/1.3588037).

180. B.M. Osende, J.P. Abraham, and G.S. Mowry, Small-Scale Use of Solar Power in Remote, Developing Regions: A Case Study, *Journal of Sustainable Development,* Vol. 4, pp. 3-9, 2011.

181. B.D. Plourde, J. P. Abraham, G. S. Mowry, and W. J. Minkowycz, An Experimental Investigation of a Large, Vertical-Axis Wind Turbine: Effects of Venting and Capping, *Wind Engineering,* Vol. 35, pp. 213-220, 2011.

182. N.N. Johnson, J.P. Abraham, Z.I. Helgeson, W.J. Minkowycz, and E. M. Sparrow, An Archive of Skin-Layer Thicknesses and Properties and Calculations of Scald Burns with Comparisons to Experimental Observations, *Journal of Thermal Science and Engineering Applications*, Vol. 3, paper no. 011003, 2011.

183. Z. Helgeson, J. Jenkins, J. Abraham, and E. Sparrow, Particle Trajectories and Agglomeration/Accumulation in Branching Arteries Subjected to Orbital Atherectomy, *Open Biomedical Engineering Journal*, Vol. 5, pp. 25-38, 2011.

184. L. Steck, E.M. Sparrow, and J.P. Abraham, Non-Invasive Measurement of the Human Core Temperature, *International Journal of Heat and Mass Transfer*, Vol. 54, pp. 949-982, 2011.

185. N. N. Johnson, J. P. Abraham, Z, I. Helgeson and M.P. Hennessey, Simulation of Embolization Particle Trajectories, *Frontiers in Heat Transfer*, Vol. 2, paper no. 023006, 2011.

186. G. Adams, P. Khanna, C. Staniloae, J.P. Abraham, and E.M. Sparrow, Optimal Techniques with the Diamondback 360 System Achieve Effective Results for the Treatment of Peripheral Arterial Disease, *Journal of Cardiovascular Translation Research*, Vol. 4, 220-229, 2011.

187. J.P. Abraham, E. M. Sparrow, and W. J. Minkowycz, Internal-Flow Nusselt Numbers for the Low-Reynolds-Number End of the Laminar-to-Turbulent Transition Regime, *International Journal of Heat and Mass Transfer*, Vol. 54, 584-588, 2011.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

188. S. Chelikani, E.M. Sparrow, J.P. Abraham, and W.M. Minkowycz, Mass Transfer in Vascular Access Ports*, International Journal of Heat and Mass Transfer*, Vol. 54, pp. 949-958, 2011.

2010

189. R. Ramazani-Red, S. Chelikani, E. M. Sparrow, and J. P. Abraham, Experimental and Numerical Investigation of Orbital Atherectomy: Absence of Cavitation, *Journal of Biomedical Science and Engineering*, Vol. 3, pp. 1108-1116, 2010.

190. A.P. Thomas and J.P. Abraham, Sawtooth Vortex Generators for Underwater Propulsion, *Open Mechanical Engineering*, Vol. 4, pp. 1-7, 2010.

191. D. K. Smith, R.D. Lovik E. M. Sparrow, and J. P. Abraham, Human Tissue Temperatures Achieved During Recharging of New-Generation Neuromodulation Devices, *International Journal of Heat and Mass Transfer,* Vol. 53, 3292-3299, 2010.

192. J. P. Abraham, E. M. Sparrow, J. C. K. Tong, and D. W. Bettenhausen, Internal Flows which Transist from Turbulent Through Intermittent to Laminar, *International Journal of Thermal Sciences*, Vol. 49, 256-263, 2010.

193. E.M. Sparrow, J.P. Abraham, Y. Bayazit, R.D. Lovik, and D.K. Smith, Numerical and Experimental Simulations as Symbiotic Tools for Solving Complex Biothermal Problems, *Journal of Medical Devices*, Vol. 4, 027536, 2010.

2009

194. R.D. Lovik, J.P. Abraham, W.J. Minkowycz, and E.M. Sparrow, Laminarization and Turbulentization in a Pulsatile Pipe Flow, *Numerical Heat Transfer Part A*, Vol. 56, 861-879, 2009.

195. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Tissue-Damage Potential from Transcutaneous Recharge of Neuromodulation Implants, *International Journal of Heat and Mass Transfer*, Vol. 52, pp. 3518-3524, 2009.

196. E.M. Sparrow, J.P. Abraham, and W.J. Minkowycz, Flow Separation in a Diverging Conical Duct: Effect of Reynolds Number and Divergence Angle, *International Journal of Heat and Mass Transfer,* Vol. 52, pp. 3079-3083, 2009.

197. F.A. Hoover and J.P. Abraham, A Comparison of Corn-Based Ethanol with Cellulosic Ethanol as Replacements for Petroleum-Based Fuels, A Review*, International Journal of Sustainable Energy*, Vol. 28, pp. 171-182, 2009.

198. G.S. Mowry, R. Erickson, and J.P. Abraham, Computational Model of a Novel, Two-Cup Horizontal Wind-Turbine System, *Open Mechanical Engineering Journal*, Vol. 3, pp. 26-34, 2009.

4232 29th Ave. **John P. Abraham** **jpabraham@stthomas.edu**
Minneapolis, MN 55406 **612-963-2169**

199. J.C.K. Tong, E.M. Sparrow, and J. P. Abraham, Geometric Strategies for Attainment of the Identical Outflows Through all of the Exit Ports of a Distribution Manifold in a Manifold System, *Applied Thermal Engineering*, Vol. 29, 3552-3560, 2009.

200. W.J. Minkowycz, J.P. Abraham, and E.M. Sparrow, Numerical Simulation of Laminar Breakdown and Subsequent Intermittent and Turbulent Flow in Parallel Plate Channels: Effects of Inlet Velocity Profile and Turbulence Intensity, *International Journal of Heat and Mass Transfer*, 52, pp. 4040-4046, 2009.

201. J.P. Abraham, G.S. Mowry, R. Erickson, Analysis of Urban Wind Turbines, Clean Technology, pp. 13-16, 2009.

202. J.P. Abraham and A.P. Thomas, Induced Co-Flow and Laminar-to-Turbulent Transition with Synthetic Jets, *Computers and Fluids*, Vol. 38, pp. 1011-1017, 2009.

203. J.P. Abraham, E.M. Sparrow, and J.C.K. Tong, Heat Transfer in All Pipe Flow Regimes - Laminar, Transitional/Intermittent, and Turbulent, *International Journal of Heat and Mass Transfer,* Vol. 52, pp. 557-563, 2009.

2008

204. J.C. Tong, E.M. Sparrow, and J.P. Abraham, Unified Treatment of Natural Convection in Tall, Narrow, and Flat, Wide Rectangular Channels, *Numerical Heat Transfer A*, Vol. 54, pp. 763-776, 2008.

205. J.P. Abraham, J.C.K. Tong, and E.M. Sparrow, Breakdown of Laminar Pipe Flow into Transitional Intermittency and Subsequent Attainment of Fully Developed Intermittent or Turbulent Flow, *Numerical Heat Transfer B*, Vol. 54, pp. 103-115, 2008.

206. J.P. Abraham, E.M. Sparrow, and R.D. Lovik, Unsteady, Three-Dimensional Fluid Mechanic Analysis of Blood Flow in Plaque-Narrowed and Plaque-Free Arteries, *International Journal of Heat and Mass Transfer*, Vol. 51, 5633-5641, 2008.

207. E.M. Sparrow, J.C.K. Tong, and J.P. Abraham, Fluid Flow in a System with Separate Laminar and Turbulent Zones, *Numerical Heat Transfer A*, Vol. 53 (4), pp. 341-353, 2008.

2007

208. J.P. Abraham and C.M. George, Full-Building Radiation Shielding for Climate Control in Desert Regions, *International Journal of Sustainable Energy*, Vol. 26 (3) pp. 167-177, 2007.

209. J.P. Abraham and E.M. Sparrow, A Thermal Ablation Model Including Liquid-to-Vapor Phase Change, Necrosis-Dependent Perfusion, and Moisture-Dependent Properties, *International Journal Heat and Mass Transfer*, Vol. 50, pp. 2537-2544, 2007.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

210. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Attainment of Flowrate Uniformity in the Channels that Link a Distribution Manifold to a Collection Manifold*, Journal of Fluids Engineering*, Vol. 129 (9), pp. 1186-1192, 2007.

211. E.M. Sparrow and J.P. Abraham, A Simulation of Gas-Based, Endometrial-Ablation Therapy for the Treatment of Menorrhagia, *Annals of Biomedical Engineering,* Vol. 36 (1), pp. 171-183, 2008

2007

212. J.P. Abraham, E.M. Sparrow, and S. Ramadhyani, Numerical Simulation of a BPH Thermal Therapy – A Case Study Involving TUMT, *Journal of Biomechanical Engineering*, Vol. 129, pp. 548-557, 2007.

213. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, A Quasi-Analytical Method for Fluid Flow in a Multi-Inlet Collection Manifold, *Journal of Fluids Engineering*, Vol. 129, pp. 579-586, 2007.

214. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Numerical Simulation of the Urine Flow in a Stented Ureter, *Journal of Biomechanical Engineering*, Vol. 129, pp. 187-192, 2007.

2006

215. J.P. Abraham, A Guide to Curing Processes, *Journal of Precision Manufacturing*, 6, pp. 16-17, 2006.

216. J.P. Abraham and C.M. George, Micro-Geothermal Devices for Low-Energy Air-Conditioning in Desert Climates, *GHC Bull.*, Vol. 27, (4), pp. 13-16, 2006.

217. P.W. Chevalier, J.P. Abraham, and E.M. Sparrow, The Design of Cold Plates for the Thermal Management of Electronic Equipment, *Journal of Heat Transfer Engineering*, Vol. 27, pp. 6-16, 2006.

2005

218. E. M. Sparrow and J. P. Abraham, Universal Solutions for the Streamwise Variation of the Temperature of a Moving Sheet in the Presence of a Moving Fluid, *International Journal of Heat and Mass Transfer*, Vol. 48, pp. 3047-3056, 2005.

219. E.M. Sparrow, J.P. Abraham, P.W. Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, *Journal of Heat Transfer*, Vol. 127, pp. 27-33, 2005.

220. J. P. Abraham and E. M. Sparrow, Friction Drag Resulting From the Simultaneous Imposed Motion of a Freestream and its Bounding Surface, *International Journal of Heat and Fluid Flow*, Vol. 26, pp. 289-295, 2005.

4232 29th Ave.
Minneapolis, MN 55406
John P. Abraham
jpabraham@stthomas.edu
612-963-2169

221. S.K. S. Boetcher, E.M. Sparrow, and J.P. Abraham, Numerical Simulation of the Radiative Heating of a Moving Sheet, *Numerical Heat Transfer*, Vol. 47, pp. 1-25, 2005.

2004

222. E.M. Sparrow, J.P. Abraham, and J.C. K. Tong, Archival Correlations for Average Heat Transfer Coefficients for Non-Circular and Circular Cylinders and for Spheres in Crossflow, *International Journal of Heat and Mass Transfer*, Vol. 47 (24), pp. 5285-5296, 2004.

223. J.P. Abraham and E.M. Sparrow, A Simple Model and Validating Experiments for Predicting the Heat Transfer to a Load Situated in an Electrically Heated Oven, *Journal of Food Engineering*, Vol. 62 (4) pp. 409-415, 2004.

224. J.P. Abraham, Teaching Case Studies to a Multi-Disciplinary Class - Bridging the Gap Between Engineering and the Biological Sciences, *Journal of College Science Teaching*, Vol. 33 (5), March/April 2004.

2003

225. E.M. Sparrow and J.P. Abraham, A Computational Analysis of the Radiative and Convective Processes Which Take Place in Preheated and Non-Preheated Ovens, *Journal of Heat Transfer Engineering*, Vol. 24, No. 5, pp. 25-37, 2003.

226. J.P. Abraham and E.M. Sparrow, Three Dimensional Laminar and Turbulent Natural Convection in a Continuously/Discretely Wall-Heated Enclosure Containing a Thermal Load, *Numerical Heat Transfer, A,* Vol. 44, pp. 105-125, 2003.

227. E. M. Sparrow and J. P. Abraham, A New Buoyancy Model Replacing the Standard Pseudo-Density Difference for Internal Natural Convection in Gases, *International Journal of Heat and Mass Transfer*, Vol. 46, pp. 3583-3591, 2003.

2002

228. J.P. Abraham and E.M. Sparrow, Experiments on discretely heated, vented/unvented enclosures for various radiation surface characteristics of the thermal load, enclosure temperature sensor, and enclosure walls*, International Journal of Heat and Mass Transfer*, Vol. 45, pp. 2255-2263, 2002.

229. J.P. Abraham and E.M. Sparrow, Fluid Flow and Heat Transfer in Multiply-Folded, Continuous Flow Passages Including Conjugate Thermal Interaction Between the Fluid and Bounding Walls, *Numerical Heat Transfer, A*, Vol. 42, pp. 327-344, 2002.

230. E.M. Sparrow, J.P. Abraham, and Molly K. Rolfsmeier, Fabric Ducts for Air Distribution and for Décor, *Fabric Architecture*, March/April 2002.

231. E.M. Sparrow and J.P. Abraham, Heat Transfer Coefficients and Other Performance Parameters for Variously Positioned and Supported Thermal Loads in Ovens

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

With/Without Water-Filled or Empty Blockages, *International Journal of Heat and Mass Transfer*, Vol. 45, pp. 3597-3607, 2002.

2001

232. E.M. Sparrow, J.C.K. Tong, and J.P. Abraham, An Experimental Investigation on a Mass Exchanger for Transferring Water Vapor and Inhibiting the Transfer of Other Gases*, International Journal of Heat and Mass Transfer*, Vol. 44, pp. 4313-4321, 2001.

233. E.M. Sparrow, G.L. Martin, J.P. Abraham, and J.C.K. Tong, Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance, *Transactions of the ASHRAE*, Vol. 107, (2) 2001.

Conference Presentations and Public Lectures

1. J.P. Abraham, Introduction to the Computational Tools Available in Fluid Mechanics and Heat Transfer Research, *National Workshop on Research Methodology in Fluid Mechanics,* Pilani, India, June 7-9, 2021.

2. L. Cheng, K. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, and J. Fasullo, Improved Estimates of Changes in Upper Ocean Salinity and Water Cycle, *AGU Fall Meeting*, 2020.

3. J.P. Abraham, The Science of Global Warming – What do we really know? *Presented at New Mexico Tech. Lecture Series*, September 24, 2020.

4. L. Cheng, K. Trenberth, K. von Schukmann, J.P. Abraham, V. Gouretski, Oceanic Responses to the Climate: Recognizing Changes and Extremes, AAAS Annual Meeting, February 11, 2021.

5. J.P. Abraham, Advanced Methods in Thermal Engineering, *International Workshop on Recent Advances in Thermal Engineering*, India, June 29-July 3, 2020.

6. J.P. Abraham, L. Cheng, Kevin Trenberth – A Life of Research and Impact, *Trenberth Symposium*, Denver, CO, March 16, 2020.

7. J.P. Abraham, Modern Climate Change, *Threats to the Worlds Oceans – World Ocean Day*, Minneapolis, MN June 8, 2020.

8. L. Cheng, K.E. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, J. Fasullo, G. Li, X. Zaho, and J. Zhu, Ocean Subsurface Salinity Changes Yield an Anthropogenic Climate Change Signal, *Ocean Sciences 2020*, San Diego, CA, February 16-21, 2020.

9. J.P. Abraham, Climate Science, Projections for the Next Two Decades, *Code Blue, Health Care Professionals for a Healthy Climate*, Minneapolis, MN, April 4, 2020.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

10. L. Cheng, G. Foster, Z. Hausfather, K.E. Trenberth, J.P. Abraham, Increase in the Rate of Ocean Warming, *2019 AGU Fall Meeting*, San Francisco, December, 9-13, 2019.

11. J.P. Abraham, G. Foster, Z. Hausfather, L. Cheng, K.E. Trenberth, Earth's Energy Imbalance abd Energy Flows Through the Climate System, *2019 AGU Fall Meeting*, San Francisco, December, 9-13, 2019.

12. L. E. Olsen and J.P. Abraham, Evaluation of CFD algorithms for solving a canonical problem of flow over a square cylinder, *4th Thermal and Fluids Engineering Conference*, Las Vegas, April 14-17, 2019.

13. S. A. Mandia, J.P. Abraham, M. Ashley, and J.W. Dash, The Climate Rapid Response Team – An Effective Model for Engaging Media and Polictmakers, *2018 AGU Fall Meeting*, Washington, DC, December 2018.

14. J.P. Abraham, Climate Change, the Evidence is in the Oceans, *Presented at the National Laboratory for Marine Science and Technology*, Qingdao, China, October 25, 2018.

15. J.P. Abraham, Progress in XBT simulations, *Presented at the Institute of Atmospheric Physics*, Beijing, October 23, 2018.

16. J.P. Abraham, B.D. Plourde, J.R. Stark, Modeling Hemodynamics Through Lesions *Cardiovascular Research Technologies Conference 18*, Washington DC., March 3-6, 2018.

17. G. Wang, L. Cheng, J.P. Abraham, C. Li, and H. Du, Consensuses and discrepancies of basin-scale ocean heat content changes in different ocean analysis, *AOGS 15th Annual Meeting*, June 3-8, Hawaii, USA, 2018.

18. K.E. Trenberth, C. Lijing, P. Jacobs, and J.P. Abraham, Are recent hurricane (Harvey, Irma, and Maria) disasters Natural? *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

19. P. Jacobs, S. Akella, K.E. Trenberth, C. Lijing, and J.P. Abraham, The Historical Context of the 2017 Hurricane Season's Ocean Warmth, *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

20. J.P. Abraham, P. Jacobs, L. Cheng, K.E. Trenberth, Are recent hurricane (Harvey, Irma, and Maria) disasters Natural? *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

21. J.P. Abraham and B.D. Plourde, Using ANSYS for Multiphysics Design of a Water Treatment System, *ANSYS Innovation Conference 2017*, Minneapolis, MN, November 8, 2017.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

22. J.P. Abraham, L.J. Cheng, K.E. Trenberth, Improved Estimates of Ocean Heat Content from 19602015, *NOAA Presentation*, Washington DC, June 22, 2017.

23. J.P. Abraham, Use of Computational Fluid Dynamics to Improve Oceanographic Measurements, *NOAA Presentation*, Washington DC, January 12, 2017.

24. J.P. Abraham, B.D. Plourde, Use of Multi-lumen Catheters to Preserve Injected Stem Cell Viability, *Cardiovascular Research Technologies Conference 17*, Washington DC., February 18-21, 2017.

25. L. Cheng, J. Zhu, K. Trenberth, J. Fasullo, M. Palmer, T. Boyer, J. Abraham, Improved Ocean Heat Content Estimation Since 1960, *AGU Fall Meeting 2016*, San Francisco, CA, 2016.

26. J.P. Abraham, B. D. Plourde, John Stark, L.J. Vallez, Using ANSYS to Reduce Costs and Speed Development Process, *ANSYS Upper Midwest Innovation Conference*, Bloomington, Minnesota, November 17, 2016 (Keynote).

27. N. Langat, T. Thoruwa, J. Abraham, J. Wanyoko, Performance of an Improved Fluidized System for Processing Green Tea, *ICEE 18th International Conference on Energy Engineering*, Toronto, Canada, 2016.

28. L. Cheng, R. Cowley. J.P. Abraham, Cold Water Biases in XBT Descent, *5th XBT Science Workshop*, Tokyo, Japan, October 3-7, 2016 (Invited).

29. L. Cheng, K. Trenberth, M. Palmer, J.P. Abraham, Historical Ocean Heat Content Estimation and the Implications for Assessing Historical Earth's Energy Budget, *Clivar 2016*, Qingdao, China, 2016.

30. R. Cowley, J.P. Abraham, L. Cheng, The Effect of Water Temperature on XBT Fall Rate, *Clivar Third IQuOD Workshop,* Hamburg, Germany, December 3-4, 2015.

31. R. Cowley, L. Cheng, G. Goni, T. Boyer, J.P. Abraham, S. Wijffels, V. Gouretski, F. Reseghetti, S. Kizu, S. Dong, F. Bringas, M. Goes, L. Houpert, J. Sprintall, J. Zhu, Towards Reducing Uncertainty in Historical XBT Data: An International Effort from the XBT Science Team, *2016 Ocean Sciences Meeting*, New Orleans, LA, February 21-26, 2016.

32. J.P. Abraham and B.D. Plourde, Novel Cost-Effective Solution for Potable Water in All Environments, *The Food-Energy-Water Nexus, 16th National Conference and Global Forum on Science, Policy, and the Environment*, Washington DC, January 18-21, 2016.

33. J.P. Abraham and B.D. Plourde, Off-Grid Wind Power Systems for the Developing World, *The Food-Energy-Water Nexus, 16th National Conference and Global Forum on Science, Policy, and the Environment*, Washington DC, January 18-21, 2016.

4232 29th Ave. **John P. Abraham** **jpabraham@stthomas.edu**
Minneapolis, MN 55406 **612-963-2169**

34. L.Cheng, J. Zhu, J.P. Abraham, An Updated Historical (1970-2014) Upper OHC Estimates and Implication for the Global Energy Budget, *Climate and Ocean Variability and Change (CLIVAR) 8th Session of the Global Synthesis*, Exeter, UK, September 28, 2015.

35. J.P. Abraham, Our Changing Climate, *Citizens Climate Lobby Conference*, Red Wing, MN, November 6, 2015.

36. J.P. Abraham, J.R. Stark, Advances in XBT Measurement and Bias Reduction, *Chinese Academy of Sciences*, Beijing, October 10, 2015.

37. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, *American Geophysical Union Fall Meeting*, San Francisco, CA, December 14-18, 2015.

38. L. Cheng, J. Zhu, and J.P. Abraham, An Updated Estimate on Global Upper Ocean Heat Content Change and the Remaining Challenges, *American Geophysical Union Fall Meeting*, San Francisco, CA, December 14-18, 2015.

39. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, *US Climate Variability and Predictability Program (CLIVAR) Summit*, Tucson, AZ, August 4-6, 2015.

40. J.P. Abraham, Small-scale Wind Turbines: Design, Analysis and Applications, *Hong Kong University*, January 28, 2015 (invited).

41. J.P. Abraham, The Science of Climate Change, What Do We Really Know, *Hong Kong University of Science and Technolog*y, January 26, 2015 (invited).

42. J.P. Abraham et al., A Novel Multi Lumen Compliant Balloon Catheter (ND® Infusion Catheter) Preserves Stem Cell Viability and Improves Dispersion When Compared to a Standard Single Lumen Balloon Angioplasty Catheter, *European Society of Cardiology*, 2015, (submitted).

43. J.P. Abraham, T.M. Shepard, W.J. Minkowycz, J.R. Stark, J. M. Gorman, Quantification of Near-Surface Impact Forces on XBTs, *The 4th XBT Workshop: XBT Science and the Way Forward,* Beijing, China, November 11-13, 2014.

44. J.P. Abraham, B.D. Plourde, S.A. Mandia, and K.E. Trenberth, Closing the Earth Energy Imbalance, *3rd International Conference on Earth Science and Climate Change,* San Francisco, CA, July 28-30, 2014.

45. J.P. Abraham, B.D. Plourde, J.R. Stark, and W.J. Minkowycz, Improvements to the Quality and Quantity of Ocean Heat Content Measurements, *3rd International Conference on Earth Science and Climate Change,* San Francisco, CA, July 28-30, 2014.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

46. J.P. Abraham, B.D. Plourde, J.R. Stark, W.J. Minkowycz, Cryosurgical Treatment of Cancer: The Importance of Modeling, *4th World Congress on Cancer Science and Therapy*, Chicago, October 20-22, 2014.

47. N. Dib, J.P. Abraham, B. D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, T. Flower, and R.E. Kohler, A Novel Multi-lumen Compliant Balloon Catheter Preserves Stem Cell Viability and Decreases Cellular Clumping When Compared to a Standard Single-lumen Balloon Angioplasty Catheter, *Transcatheter Cardiovascular Therapeutics (TCT 2014)*, Washington, DC, September 13-17, 2014.

48. N. Dib, J.P. Abraham, B. D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, T. Flower, and R.E. Kohler, A Novel Multi-lumen Compliant Balloon Catheter Preserves Stem Cell Viability and Decreases Cellular Clumping When Compared to a Standard Single-lumen Balloon Angioplasty Catheter, *Complex Cardiovascular Therapeutics*, Orlando, FL, June 23-27, 2014.

49. J.P. Abraham, The Science of Climate Change (Keynote*), 2014 Summer Institute for Climate Change and Energy Education*, Sandstone, MN, August 4-6, 2014.

50. J.P. Abraham, D. B. Schwalbach, T. M. Shepard, J. M. Gorman, Calculating forces of impact as objects travel from air into water at high velocity, *ANSYS Regional Conference*, Minneapolis, MN, June 10, 2014.

51. B.D. Plourde, D.B. Schwalbach, J.P. Abraham, R.E. Kohler, and N.N. Johnson, Intracoronary Injection of Medication from multi-lumen injection Catheters, *Design of Medical Devices 2014*, April 7-14, Minneapolis, MN.

52. N. Dib, J. Abraham, B.D. Plourde, D.S. Schwalbach, D. Dana, D. Lester, T. Flowers, and R.E. Kohler, Comparison of the Stem Cell Viability and Shear Stress of Single Lumen and Multi Lumen Balloon Infusion Catheter for Intra-Arterial Stem Cell Infusion, *American Cardiology Conference 2014*, Washington, DC, March 29-31.

53. J.P. Abraham, The Science of Global Warming, What Do We Really Know (Keynote)*, Audubon Society National Meeting*, October 6, 2013.

54. J.P. Abraham, Thawing Out Climate Science, IEEE 2013 Awards Banquet, St. Paul, MN, February 23, 2013.

55. J.P. Abraham, Using ANSYS to Model Rotating Oceanographic Devices, *ANSYS Regional Conference*, Minneapolis, June 6, 2013.

56. N. Dib, J.P. Abraham, B. Plourde, D. Schwalbach, D. Dana, L. Myers, T. Flowers, and R. Kohler, Stem Cell Viability Significantly Reduced After Passing Through a Standard Single Lumen Over-the-wire 0.014 inch Balloon Angioplasty Catheter, *TCT 2013 Conference*, October 27-November 1, 2013, San Francisco, CA.

4232 29th Ave. **John P. Abraham** **jpabraham@stthomas.edu**
Minneapolis, MN 55406 **612-963-2169**

57. J.P. Abraham, Measurements of the Earth's Climate System, *IEEE Conference on Instrumentation and Measurement Technology Conference*, Minneapolis, MN, May 6, 2013.

58. J.P. Abraham, Numerical Simulations of Drug Deposition of Paclitaxel, *Design of Medical Devices Conference*, 2013, Minneapolis, MN, April 8-11, 2013.

59. J.P. Abraham, J. Stark, J. Gorman, E. Sparrow, R. Kohler, A Model of Drug Deposition Within Artery Walls, *Design of Medical Devices Conference*, 2013, Minneapolis, MN, April 8-11, 2013.

60. J.L. Conroy, S.A. Mandia, J.P. Abraham, S.E. Moffitt, G. Tootle, Environmental Litigation and the Role of Climate Scientists, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

61. S.A. Mandia, J. Abraham, J. Dash, M. Ashley, Filling the Knowledge Gap that Exists Between the Public and Its Leaders and Climate Science Experts, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

62. S.A. Mandia, J.P. Abraham, J. Dash, and M. Ashley, Navigating Negative Conversations in Climate Change, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

63. M.J. Kallock, A. Yevzlin, M. Nelson, and J.P. Abraham, Numerical Modeling of Blood Flow in a New Percutaneously Delivered Hemodialysis Shunt, *BMES 2012 Annual Meeting*, Atlanta Georgia, October 24-27, 2012.

64. J.P. Abraham, Understanding Climate Change's Common Myths, *Minnesota Broadcast Meteorologists Climate Change Science Seminar*, St. Paul, MN, October 5-6, 2012.

65. N.P. Sullivan, J.E. Wentz, J.P. Abraham, Multi-Scale Modeling of Tubular Cross-Flow Microfiltration of Metalworking Fluids, *ASME International Mechanical Engineering Congress and Exposition*, Houston, TX, November 9-15, 2012.

66. J.P. Abraham, M. Nelson, J. Jeske, J. Gorman, Simulation Tools for Design and Testing Substitution in Medical Devices, *Lifescience Alley Research Conference, Research and Development 101*, Minneapolis, MN, May 22, 2012.

67. M.J. Kallock, M. E. Nelson, J. P. Abraham, and A. S. Yevzlin, Fluid Mechanic Modeling of a Percutaneously Delivered Vascular Access Device, *American Society of Diagnostic and Interventional Nephrology, 8th Annual Meeting,* New Orleans, LA, February 24-26, 2012.

68. D. Dana, J.P. Abraham, R. Kohler, A. Campbell, B. Baird, M. Olson, and N. Dib, A Novel Catheter Delivery System (CardioDib) That May Enable Intracoronary Stem Cell Infusion by Possibly Minimizing Cellular Clumping and Distal Embolization

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

(DE) While Preserving Cellular Viability, *9th International Symposium on Stem Cell Therapy and Cardiovascular Innovations*, Madrid, Spain, June 7-8, 2012.

69. K.E. Trenberth, K. Emanuel, J.P. Abraham, Climate Science and Meteorology, *AMS National Broadcast Meteorology Conference*, Boston, MA, August 24, 2012

70. J.P. Abraham, J. Jeske, and M. Nelson, Thermal and Fluid Flow Simulations in Health Care: Product Development and Safety Improvement, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

71. J.P. Abraham, Climate Myths, Misconceptions, and Their Creators, American Chemical Society, St. Paul, MN, November 13, 2012.

72. I. Enting, J.P. Abraham, Detailed Debubnking of Denial, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

73. B.D. Plourde, J.P. Abraham, G.S. Mowry, E.M. Sparrow, Experimental Test of Multi-Stage Vertical-Axis Turbines for Cellular Communication Applications, *ASME 6th International Conference on Energy Sustainability*, San Diego, CA, July 23-26, 2012.

74. M.N. Nelson and J.P. Abraham, Hemodynamics of AV Grafts for Hemodialysis Access, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

75. J.P. Abraham and J.S. Jeske, Cryosurgical Simulations for Ablation of Kidney Tumors, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

76. J.P. Abraham, J.R. Stark, and J.M. Gorman, Drag Calculations on Oceanographic Devices, *ANSYS Regional Conference,* Minneapolis, MN, October 20, 2011.

77. J.P. Abraham, B.D. Plourde, and G.S. Mowry, Fluid Dynamic Simulations of Wind Turbines, *ANSYS Regional Conference,* Minneapolis, MN, October 20, 2011.

78. S.A. Mandia, J.P. Abraham, R. Weymann, and M. Ashley, The Climate Science Rapid Response Team – A Model for Science Communication, *Geological Society of America Annual Meeting and Exposition,* Minneapolis, MN, October 9-12, 2011.

79. S.A. Mandia, J.P. Abraham, R.J. Weymann, and M. Ashley, The Climate Sciences Rapid Response Team – A Model for Science Communication, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

80. J.P. Abraham, J. Stark, J. Gorman, F. Reseghetti, J. Willis, and J. Lyman, Preliminary Fluid Drag Calculations for Expendable Bathythermograph Devices, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

81. S.A. Mandia, J.P. Abraham, R.A. Weymann, and M. Ashley, Scientists Shaping the Discussion, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

82. J.P. Abraham, J.R. Stark, J.M. Gorman, F. Reseghetti, J. Willis, and J. Lyman, Computational Modeling of Probe Dynamics to Improve Ocean Heat Content Measurements, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

83. B.M. Osende, J.P. Abraham, and G.S. Mowry, The Design, Installation, and Maintenance of a Village-Sized Solar Power System in Uganda, *Nanotech, Cleantech, Microtech 2011 Conference*, June 13-16, 2011, Boston, MA. Published in the Technical Proceedings of the 2011 NSTI Nanotechnology Conference and Expo, Vol. 3, pp. 755-758, 2011.

84. J.M. Gorman, E.M. Sparrow, G.S. Mowry, and J.P. Abraham, Simulation of Helically Wrapped, Compact Heat Exchangers, ASME 2011 Energy Sustainability *Conference*, Washington, DC, August 7-10, 2011.

85. B.D. Plourde, J.P. Abraham, G.S. Mowry, and W.J. Minkowycz, Vertical-Axis Wind Turbines for Powering Cellular Communication Towers, *Nanotech, Cleantech, Microtech 2011 Conference*, June 13-16, 2011, Boston, MA. *Published in the Technical Proceedings of the 2011 NSTI Nanotechnology Conference and Expo*, Vol. 3, pp. 750-753, 2011.

86. L. Tran, M.P. Hennessey, and J.P. Abraham, Simulation and Visualization of Dynamic Systems: Several Approaches and Comparisons, *ASME International Mechanical Engineering Congress and Expo*, Vancouver, Canada, November 12-18, 2011.

87. J.P. Abraham, Global Warming, What does the Science Tell Us?, *7th Annual Environmental Institute Conference* (KEYNOTE), Minneapolis, MN, April 21, 2010.

88. J.P. Abraham, G.S. Mowry, B.D. Plourde, and W.J. Minkowycz, Numerical Simulations of Vertical-Axis Wind Turbine Blades, *ASME 2011 Energy Sustainability Conference and Fuel Cell Conference*, Washington, DC, August 7-10, 2011.

89. J.P. Abraham, G.S. Mowry, B.D. Plourde, and W.J. Minkowycz, Wind Tunnel Tests of Vertical-Axis Wind Turbine Blades, *ASME 2011 Energy Sustainability Conference and Fuel Cell Conference*, Washington, DC, August 7-10, 2011.

90. R.D. Lovik, E.M. Sparrow, J.P. Abraham, C.L. Zelmer, S.K.S. Friend, and D.K. Smith, Effect of Component Misalignment on Human Tissue Temperatures Associated with Recharging Neuromodulation Devices, *Design of Medical Devices Conference*, Minneapolis, MN April 12-14, 2011.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

91. N.N. Johnson, K. L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgical Treatments for Uterine Fibroids, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

92. R.D. Lovik, K. J. Kelly, E.M. Sparrow, and J.P. Abraham, Effect of Misalignment of Implant and Antenna on Heat Generation of Externally Recharged Neuromodulation Implants, *North American Neuromodulation Society 14th Annual Meeting*, Las Vegas, NV, December 2-5, 2010.

93. J.P. Abraham and S. Mandia, An Emerging Ethic of Responsibility: A Case Study for Engaging the Public, *American Geophysical Union Fall Meeting*, San Francisco, CA December 13-17, 2010.

94. J.P. Abraham and G.S. Mowry, B.D. Plourde, Analysis of Thermal and Fluid Flow Problems, *Thermal Packaging and Small Business Innovation Workshop*, Eagan, MN, October 5-6, 2010.

95. N.N. Johnson, J.P. Abraham, Z.I. Helgeson, and M.P. Hennessey, Numerical Simulation of Blood Flow in the Presence of Embolizing Agents, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

96. N.N. Johnson, J.P. Abraham, and Z.I. Helgeson, Calculations of Scald Burns: Effects of Water Temperature, Exposure Duration, and Clothing, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

97. N.N. Johnson, M.P. Hennessey, and J.P. Abraham, Swept Arc Length Measure of Abrasive Wear, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

98. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Numerical Simulation of Cryosurgery as a Potential Treatment for Uterine Fibroids, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

99. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 1: Hydrodynamic and thermal Modeling of Steady, Intermittent Flows in Constant Area Ducts, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

100. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 2: Time-Varying Flows and Flows in Variable Area Ducts, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

101. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgery as an Alternative Treatment for Menorrhagia and Uterine Fibroids, *ASME Summer Biomedical Engineering Conference*, Naples, FL, June 16-19, 2010.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

102. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Analysis of Drag-Reducing Techniques for Olympic Skeleton Helmets, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

103. B. D. Plourde, J.P. Abraham, G.S. Mowry, Numerical Simulation of Vertical Axis Wind Turbines, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

104. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, Numerical Simulations and Medical Device Design, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

105. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Drag-Reducing Vortex Generators and Olympic Skeleton Helmet Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.

106. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, (Keynote), Numerical Simulations in Biomedical Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.

107. J.P. Abraham, E.M. Sparrow, Y. Bayazit, R.D. Lovik, and D.S. Smith, Numerical and Experimental Simulations as Symbiotic Tools for Solving Complex Bio-Thermal Problems, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.

108. E.M. Sparrow and J.P. Abraham, Numerical Solutions of Biological Heat Transfer, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.

109. J.P. Abraham, R.D. Lovik, D.S. Smith, E.M. Sparrow, and K.J. Kelly, Heat Generation Measurements of Revised Neuromodeulation Devices and Calculations of Tissue Temperatures, *North American Neuromodulation Society 13th Annual Meeting*, Las Vegas, December 3-6, 2009.

110. J.P. Abraham and E.M. Sparrow, Numerical Simulation as a Tool for Assessing Thermal- and Fluid-Based Processes and Therapies, *Institute for Engineering in Medicine Innovation Showcase*, Minneapolis, MN, September 22, 2009.

111. J.P. Abraham, E.M. Sparrow, and R.D. Lovik, An Investigation of Tissue-Temperature Elevation Caused by Recharging of Transcutaneous Nueromodulation Devices, *31st Annual International Conference of the IEEE Engineering in Medicine in Biology Society*, Minneapolis, MN, September 2-7, 2009.

112. R.D. Lovik, J.P. Abraham, and E.P. Sparrow, Pulasting Fluid Flows Undergoing Transitions Between Laminar, Transitional, and Turbulent Regimes, *ASME 2009 Summer Bioengineering Conference*, Lake Tahoe, CA, June 17-21, 2009.

113. E.M. Sparrow, and J.P. Abraham, Case Studies on the Use of Numerical Simulation for design and Optimization of Medical Devices, *Design of Medical Devices Conference*, Minneapolis, MN April 14-16, 2009.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

114. F. Hoover and J. Abraham Assessment of the Carbon Dioxide and Energy Balances of Biofuels, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.

115. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine for Rooftop Power Generation, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.

116. F. Hoover and J.P. Abraham, A review: Comprehensive Comparison of Corn-based and Cellulosic-based Ethanol as Biofuel Sources, *Clean Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.

117. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine, Clean *Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.

118. J.P. Abraham, R.D. Lovik, and E.M. Sparrow, Tissue Temperature Rises Due to Heat Generation in Neuromodulation Implants, North American Neuromodulation Society 12th Annual Meeting, Las Vegas, December 4-7, 2008.

119. G. Nelson, A. Majewicz, and J.P. Abraham, Numerical Simulation of Thermal Injury to the Artery Wall During Orbital Atherectomy, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

120. J.P. Abraham, Integrating Integration of ANSYS/CFX into Classrooms, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

121. J.P. Abraham, Pressure Drop and Heat Transfer Calculations for Laminar-Turbulent Intermittent Flows, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

122. J.P. Abraham, J.C.K. Tong, and E.M. Sparrow, Prediction of Laminar-Turbulent Transition and Friction Factors in Transitional Flows, *ASME International Congress and Expo*, Boston, MA, October 31 – November 5, 2008.

123. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Assessment of Possible Thermal Damage of Tissue Due to Atherectomy by Means of a Mechanical Debulking Device, *ASME 2008 Summer Bioengineering Conference*, Marco-Island, FL, June 25-29, 2008.

124. J.P. Abraham and A.P. Thomas, Numerical Simulation of Induced Co-Flow and Laminar-to-Turbulent Transition Associated with Synthetic Jets, *Flucome 2007*, Tallahassee, FL, September 16-19, 2007.

125. J.P. Abraham and C.M. George, An Investigation of Radiation Shields for Full-Building Cooling in Desert Climates, *Solar 2007*, Cleveland, OH July 7-12, 2007.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

126. A. Marchese, J.P. Abraham, C.S. Greene, L. Kizenwether, and J. Ochs, Toward a Common Standard Rubric for Evaluating Capstone Design Projects, *National Capstone Design Course Conference*, Boulder, CO June, 13-15, 2007 (Best Paper Award).

127. John Abraham, Chris Greene, Anthony Marchese, External Assessment Through Peer-to-Peer Evaluation of Capstone Projects, *Frontiers in Education*, Milwaukee, WI, October, 10-13, 2007.

128. John Abraham, Computation Fluid Dynamics Using ANSYS CFX, presented at the University of Minnesota Digital Technology Center, Sept. 12 and 14, 2006.

129. John Abraham, Application of the Finite Element Method, *LifeSciences Conference*, Minneapolis, October 5, 2006.

130. John Kim and John Abraham, Design of Experiments in the Medical Device Industry, *LifeSciences Conference*, Minneapolis, October 5, 2006.

131. Ephraim Sparrow, Nick Whitehead, and John Abraham, Fluid Flow Dynamics in the Urinary Tract – Impact on Device Design, Presented to the Department of Urologic Surgery, April 17, 2006.

132. John Abraham, Nick Whitehead, and Ephraim Sparrow, Numerical Simulation of Thermal Therapies, Presented to the Department of Urologic Surgery, April 17, 2006.

133. John Abraham, Nick Whitehead, and Ephraim Sparrow, Biomedical Applications Simulations/Experimental Investigations, *Biomedical Focus 2006*, Brooklyn Center, MN, March 20-21, 2006.

134. Nick Whitehead, Ephraim Sparrow, and John Abraham, A Role for Engineering in Medical Simulations, *Simulation in Healthcare*, Minneapolis, MN, November 28, 2005.

135. Ronald Major and John Abraham, The Application of Thermal Analysis on a Disk Array, *Fluent's 2005 CFD Summit*, Detroit, MI, June 7-8, 2005.

136. Camille George and John Abraham, A Sustainable Low-Energy Cooling System for Hot Dry Climates, *Sustainability as Security*, Austin, TX, October 5-9, 2005.

137. John P. Abraham and Ephraim M. Sparrow, Irrelevance of the Relative Velocity as the Characteristic Velocity When Both a Fluid and its Bounding Surface are in Motion, *Lorenz G. Straub Award*, Minneapolis, MN, November 13, 2004.

138. John P. Abraham and Ephraim M. Sparrow, An Unexpected U-Turn After an Eckert Straight Start, *Eckert Symposium*, Minneapolis, MN, September 13-14, 2004.

4232 29th Ave. **John P. Abraham** **jpabraham@stthomas.edu**
Minneapolis, MN 55406 **612-963-2169**

139. John P. Abraham and Ephraim M. Sparrow, Methodologies to Enhance the Numerical Simulations of Electronic Cooling, *Semi-Therm Conference,* San Jose, CA, March 9-10, 2004.

140. Ephraim M. Sparrow, John P. Abraham, and Paul Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.

141. J. P. Abraham, Ephraim M. Sparrow, Student-Related Research "Thermal Design Capstone Projects", *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.

142. Sparrow, E.M., Martin, G.L., Abraham, J.P., and Tong, J.C., Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance. *American Society of Heating, Refrigeration, and Air-Conditioning Engineers Annual Meeting*, Inc., Cincinnati, OH, ASHRAE Symposium Paper, 2001.

143. Tamma, K.K., Zhou, X., Abraham, J., and Anderson, C.V.D.R., Constitutive Model Theories and Plausible Propositions/Challenges to Heat Transport Characterization. *ASME/JSME Joint Thermal Engineering Conference*, March, 1999.

Granted Patents

1. Robert Monson and John Abraham, "Dual-phase thermal electricity generator", U.S. Patent # 8,484,974.

2. Robert Monson and John Abraham, "Variable Orifice Valve", U.S. Patent # 7,559,485

3. Robert Monson, John Abraham, Joseph Crimando, Joel Farley, Matthew Linder, and Joel Seipel, "Vehicle Energy Absorption Apparatus", US Patent # 8,118,255.

4. B.D. Plourde and J.P. Abraham, "Rotor Blade for Vertical Axis Wind Turbine", US Patent # 9,482,204/ WO 2011150171.

5. B.D. Plourde, J.P. Abraham, D.R. Plourde, A. Gikling, R. Pakonen, "Dual-Axis Tracking Device", US Patent # 10,168,412.

6. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Control Valve Assembly for Fluid Heating System", US Patent # 10,495,720.

7. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Dual Axis Tracking Device", China National Intellectual Property Administration, Patent number ZL201580075224.1, 2020.

8. B.R. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Dual Axis Tracking Method", U.S. Patent 10,890,645.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

9. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, US Patent Application Number 15/818,052, filed November 20, 2017; PCT Application Number US2017/062558, filed November 20, 2017. (Patent granted, number forthcoming).

10. B.D Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, Fluid Heating system, European Patent, granted, number forthcoming, 2021.

11. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, “Method of Calculating Pathogen Inactivation for Fluid Heating System”, US Patent, 11,092,558.

12. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, China National Intellectual Property Administration, Chinese Application Number 201780083752.0

13. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, African Regional Intellectual Property Organization (ARIPO), (patent granted, number forthcoming).

Pending Patents

1. B.D. Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, “Fluid Heating System”, US Patent Application Number 14/954,292, filed December 1, 2015.

2. B.D. Plourde, J.P. Abraham, “Solar Heating System”, US Patent Application No. 62/423,814 (filed November 18, 2016).

3. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Solar Heating for Refrigeration and Fluid Heating Devices”, filed March 2018.

4. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Dual-Axis Tracking Method”, US Application number 2019/0107598, filed November 2018.

5. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, US Application number 2018/0142905, filed November 2017.

Granted Trademarks

1. US Trademark Registration Number 5656322, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

2. US Trademark Registration Number 5656323, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

CONSULTANTSHIPS

GRANTS (funding $3.967 million)

Biotronik	**2021**
Starky	**2020**
Marvin Windows	**2020**
Cardiovascular Systems, Inc.	**2019-2021**
ALS Consulting	**2019**
Medivators	**2018-2019**
Medivators, MN	**2014-2015**
EKOS, MN	**2018**
Marcor	**2018**
Marvin Windows	**2018**
Medtronic, Fridley, MN	**2017-2020**
Orbital ATK	**2017-2018**
Pride Engineering, MN	**2017-2018**
Cargill, MN	**2016-2017**
EKOS, MN	**2016-2017**
Precision Air, MN	**2016**
3M, MN	**2015-2017**
Flourescence, Inc., MN	**2015**
Smiths Medical, MN	**2014-2015**
WTS LLC, MN	**2014-2020**
Somnetics, MN	**2014**
Lake Region Medical, MN	**2013-2014**
Amphora Medical, MN	**2013-2014**
ALS Consulting, MN	**2013-2016**
Medtronic, Fridley, MN	**2013-2016**
Devicix, MN	**2012-2013**
CriticCare, MN	**2012**
HRST, Inc., MN	**2012-2015**
QIG Group, OH	**2011-2013**
Phraxis, MN	**2011-2012**
Cardiovascular Systems, Inc., Roseville, MN	**2007-2015**
Translational Biologic Infusion, AZ	**2011-2013**
Galil Medical, Roseville, MN	**2011**
Imation, Oakdale, MN	**2010**
Medtronic, Fridley, MN	**2008-2011**
R4 Engineering, India	**2008-2009**
Horizontal Winds,	**2008-2009**
Lockheed Martin, Eagan, MN	**2007-2009**
St. Jude Medical, Minnetonka, MN	**2007-2009**
Arizant Medical, Eden Prairie, MN	**2006**
Johnson and Johnson, Newark, NJ	**2004-2005**
Cortron/XeteX, Fridley, MN	**2005**
MicroControl Company, MN	**circa 2001**
Donaldson Co., Bloomington, MN	**1999-2003**

4232 29th Ave.
Minneapolis, MN 55406
John P. Abraham
jpabraham@stthomas.edu
612-963-2169

Augustine Medical, Eden Prairie, MN	**2000-2003**
Midmac Systems Inc., St Paul, MN	**2002**
Remmele Engineering Inc., St Paul, MN	**2002-2005**
Urologix, Minneapolis, MN	**circa 2004**
Restore Medical, Minneapolis, MN	**circa 2002**
Caterpillar, Minneapolis, MN	**circa 2000**
ADC telecom, Minneapolis, MN	**circa 2000**
Entropy Solutions	**circa 2000**
XeteX, Inc., Minneapolis, MN	**1996-2000**
Pneuseal, St. Paul, MN	**1996-1998**
Los Alamos National Laboratory, Los Alamos, NM	**1994**

GRANTS (funding $3.962 million)

Biotronik **2021**
$44k for simulation of heating caused by implanted medical devices

Flotherm (SBIR award FAIN 2034065) **2020-2021**
$48k for simulation of body-heating devices
SBIR funding, NSF Small Business Innovative Research project

Starky **2019-2020**
$6k for thermal modeling of hearing aid batteries

National Science Foundation (Co-PI, FAIN = 2018403) **2020-2021**
$424k for engineering PIV instrumentation

Intertek **2019-2020**
$13k for study of tissue surrogates for biological heating

Cardiovascular Systems, Inc. **2019-2021**
$13k for thermal model of blower impellor for a dialysis pump
$9k for thermal model of blower impellor for a dialysis pump
$4k for thermal model of blower impellor for a dialysis pump
$20k for flow model of blower impellor for a dialysis pump
$5k for flow model of blower impellor for a dialysis pump

ALS Consulting **2019**
$15k for thermal model of power plant

Medivators **2019**
$12k for thermal model of thermal sterilization

Marvin Windows **2019**
$5k for thermal model of manufacturing line
$4k for thermal model of manufacturing line

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

Medtronic **2019**

$22k for simulation of tissue temperatures during transcutaneous recharge
$25.5k for simulation of tissue temperatures during transcutaneous recharge

Medivators **2018**

$18k to research airflow in medical sterilization equipment.

Marvin Windows **2018-2020**

$6k to research thermal processes during window ventillation
$4k to research thermal processes of natural lighting
$4k to research thermal processes of natural lighting

Medtronic **2018**

$3k to research battery heating rates
$8k to research thermal tolerance of brain tissue

EKOS **2018**

$14k for analysis of flow distribution within stents

Marcor **2018**

$10k for fluid and heat transfer analysis

Pride Engineering **2017**

$3k to calculate a metal stamping machine process

Orbital ATK **2017-2018**

$30k to simulate fluid flow
$12k to simulate fluid flow

Medtronic **2017**

$5k to research thermal tolerance of brain tissue
$14k to calculate cranial temperature increases during transcranial recharge

3M **2017**

$14k to simulate airflow in ultra-clean operating rooms.

Zoll Engineering **2017**

$5.5k for design of flow through a ventilation medical device

Cargill **2016-2017**

$14k for analysis of food frier
$15k for analysis of a food processing device

EKOS **2017**

$14k for analysis of flow distribution within stents
$14k for analysis of flow distribution within stents

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

$12k for analysis of flow distribution within stents

ALS Consulting **2016**
$15k for analysis of fluid flow in power plants

Precision Air **2016**
$1600 for simulation of airflow in operating rooms

Medtronic **2016**
$12k for simulation of tissue temperatures during transcutaneous recharge

3M **2015**
$12k to simulate airflow in ultra-clean operating rooms.

Cardiovascular Systems, Inc. **2015-2016**
$8,000 for the study of deformable arteries
$6,000 for biological flows and impellor design

AF Energy **2015**
$3000 wind turbine calculations

Intellectual Ventures Laboratory **2015**
$2000 wall condensation calculations

Medivators **2015**
$4000 for flow and pressure calculations medical chamber.

Floursecence, Inc. **2015**
$2,000 designing biological heater for cell environments

Mador Technologies **2015**
$20,000 analyzing a liquid nitrogen water condensation device

Koronis Biomedical Technologies **2015**
$5,000 simulation of fluid flow

Mador Technologies **2014-2015**
$8,000 analyzing a liquid nitrogen water condensation device

National Resources Defense Council **2015**
$10k for climate education work

Medtronic **2014**
$12k for simulation of tissue temperatures during transcutaneous recharge

Smiths Medical **2014**
$9.5k for design and optimization of medical warming blankets

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

$10k for the design and improvement of medical fans
$12kfor the design and analysis of human thermal analogs

WTS LLC **2014-present**
$1.5m for the design of solar pasteurization systems

Medivators **2014**
$4000 for flow and pressure calculations medical chamber.
$3000 for flow and pressure calculations medical chamber.

Somnetics **2014**
$6000 for flow and pressure calculations in CPAP devices.

Lake Region Medical **2013-2014**
$4500 for simulations of a guidewire manufacturing oven

Amphora Medical **2013-2014**
$55.5k for design of RF probes for ablation of bladder tissue

ALS Consulting **2013-2014**
$17.5k for analysis of fluid flow in power plants

Medtronic, Inc. **2012-2013**
$13k for analysis of subdermal heating associated with recharge of neuromodulation systems.

Phraxis **2013**
$2,250 for the analysis of blood flow through an AV shunt

Translational Biologic Infusion Catheter **2011-2013**
$21.5k for the study of flow and pressure drop in a stem-cell delivery catheter

Advanced Circulatory Systems, Inc. **2013**
$4200 for fluid flow modeling of medical-device blowers

HRST, Inc. **2012-2015**
$11,250 for analysis of flow patterns in manifolds

Devicix **2012**
$2000 for the analysis of medical-fluid injection devices

Helical **2012-2013**
$18,200 for the design and analysis of rooftop wind turbines

QiG Group **2012**
$7000 for study of thermoelectric technologies to power implants

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

HRST, Inc. **2012**
$4300 for analysis of perforated plates for flow uniformity

Energy Foundation **2012-2013**
$30k developing climate-science communication strategies

CriticCare **2012**
$4,275 for numerical modeling of accelerated aging of medical devices.

HRST, Inc. **2012**
$5,540 for research study on mixing efficiency in heat recovery plants.

Windstrip, LLC **2009-2013**
$1m for development of vertical axis wind turbines to power cellular communiation equipment.

QiG Group **2011-2012**
$20k for study of implant heating of biological tissue

Phraxis **2011-2012**
$8,000 for the analysis of blood flow through an AV shunt

Energy Foundation **2011-2012**
$71k developing climate-science communication strategies

Cardiovascular Systems, Inc. **2011**
$23k for the study of paclitaxel distribution techniques.

Cardiovascular Systems, Inc. **2011**
$5,000 for the study of temperature management in palleted products

Galil Medical **2011**
$9,000 for the kidney tumor cryosurgical devices.

Multiple groups **2010**
$13,000 for installation of solar panels in Uganda

Imation
$10k for the design of a polymeric extrusion die **2010**

Cypress Wind
$30.6k for the development of a vertical axis, small-footprint wind turbine. **2010**

Cypress Wind
$27k for the development of a vertical axis, small-foorprint wind turbine. **2009**

Cardiovascular Systems, Inc. **2009**

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

$80k for the study of cavitation and bolus formation during orbital atherectomy procedures.

Medtronic, Inc.
$65k for analysis of subdermal heating associated with recharge of neuromodulation systems. **2008-2011**

University of St. Thomas Faculty Development Grant **2009**
$4,200 for the purchase of a high-performance computer for numerical simulations.

CSUMS: A computational Traininig and Interdisciplinary Research Program for Undergraduates in the Mathematical Sciences at the University of St. Thomas **2008-2013**
Served as Senior Personnel on a $716,836 NSF award for the development of applied research projects for undergraduates in mathematics.

Lockheed Martin Innovative Program - Advanced Cooling Technology grant **2009**
$19.5k for the improvements to avionics heat pipe applications.

Horizontal Winds **2008-2009**
$11k for research on vertical-axis wind turbines

R4 Engineering **2008-2009**
$10k for analysis of building-support insulation systems

Lockheed Martin Innovative Program - Advanced Cooling Technology grant **2007**
$53k for the development of advanced electronic-cooling methodologies.

Arizant Medical **2006**
Characterization of a forced-air patient warming device

Johnson and Johnson, Newark, NJ **2004-2005**
Analysis of a uterine fibroid embolization device

Urologix **circa 2004**
Design of thermoelectric device for heating/cooling of urological catheter fluids

Donaldson Co. **1999-2003**
Analysis and characterization of a filter-manufacturing device

Augustine Medical **2000-2003**
Characterizsation of a forced-air patient warming device

Midmac Systems Inc. **2002**
Thermal analysiss of a polymeric sealing machine

Restore Medical **circa 2002**
Characterization of sleep apnea treatment

4232 29th Ave.
Minneapolis, MN 55406

John P. Abraham

jpabraham@stthomas.edu
612-963-2169

Remmele Engineering Inc. **2002-2005**
Thermal analysis of a polymeric sealing machine for insulin packaging

MicroControl Company **Circa 2001**
Analysis of burn-in board devices

Caterpillar **circa 2000**
Analysis of a screed heating machine

ADC Telecom **circa 2000**
Optimization of an AC/DC power converter

Entropy Solutions **circa 2000**
Design and Analysis of insulation and phase change thermal management for shipping containers

XeteX, Inc **1996-2000**
Desing of an air-to-air heat exchanger
Creation of a film processing machine for coating heat exchangers
Construction and operation of a full-sized HVAC test facility

Pneuseal **1996-1998**
Operation and optimization of a polymeric sealing device for medical packageing

Principal Investigator – Supercomputing Institute **2002-2012**
Served as PI for multi-year project dedicated to performing computational fluid dynamic studies. This grant awarded computing resources at the Supercomputing Institute for Digital Simulation and Advanced Computing.

Principal Investigator – ASHRAE Project Grant Program **2003**
Awarded a $5,000 grant funded by ASHRAE to investigate the efficacy of rotating-wheel heat and moisture exchangers.

Faculty Advisor – Bush Grant, Young Scholars Program **2002**
Faculty advisor for a $3,000 grant for undergraduate research of air-jet heat transfer for surgical applications.

Faculty Advisor – Bush Grant, Young Scholars Program **2002**
Faculty advisor for a $3,000 grant for undergraduate research to encourage American Indian students to pursue careers in science and technology.

A Multi-Function Heat Exchanger for Control of Temperature, Moisture, and Air Quality **1997-2000**
Project Engineer for $475K SBIR grants awarded by NSF, grant nos. 9660900 and 9801062

APPENDIX B

MATERIALS CONSIDERED

- U.S. Patent No. 8,240,362
- File History of U.S. Patent No. 8,240,362
- U.S. Patent No. 10,613,601
- File History of U.S. Patent No. 10,613,601
- U.S. Patent No. 10,599,196
- File History of U.S. Patent No. 10,599,196
- U.S. Patent No. 10,078,354
- File History of U.S. Patent No. 10,078,354
- U.S. Patent No. 10,078,355
- File History of U.S. Patent No. 10,078,355
- U.S. Patent No. 6,894,899 (Wu)
- U.S. Patent No. 6,019,165 (Batchelder)
- JP 2002-151638 (Shin)
- KR 2003-0031027 (Ryu)
- U.S. Patent Application No. 2004/0052663 (Laing)
- ZL 02241576.9Y (Yu)
- JP 2002-151638 (Shin)
- U.S. Patent No. 7,544,049 (Koga)
- U.S. Patent Application 2006/0185830 (Duan)
- U.S. Patent 6,915,653 (Nakano)
- Kandlikar and Grande, "Evolution of Microchannel Flow Passages – Thermohydraulic Performance and Fabrication Technology," Heat Transfer Engineering, Vol. 24, (1), 2003
- Final Written Decisions in IPR2020-00522 and IPR2020-00523
- CoolIT's Invalidity Contentions
- Asetek's Infringement Contentions
- Asetek's Response to CoolIT's Interrogatory No. 7